MARDI Res. J. 19(1) (1991): 129–135

Chemical, microbiological and sensory quality changes of semi-cooked "roti canai" during low temperature storage

(Perubahan kimia, mikrobiologi dan nilai rasa roti canai semasa penyimpanan pada suhu rendah)

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Key words: "roti canai", quality changes, low temperature storage

Abstrak

Roti canai yang separuh masak dan dibungkus dengan beg polietilena ketumpatan tinggi telah disimpan pada suhu –10 hingga –12, 2–4 dan 9–11 °C untuk 90 hari. Perubahan kimia, mikrobiologi dan nilai rasa telah dikaji pada hari penyimpanan yang ke-5, ke-14, ke-18, ke-23, ke-28, ke-36, ke-60 dan ke-90. Kajian mikrobiologi menunjukkan bahawa ketiga-tiga suhu penyimpanan kurang memberi kesan terhadap perubahan bilangan mikroorganisma di dalam roti canai. Ujian nilai rasa dari segi warna, tekstur, rasa dan penerimaan keseluruhan tidak menunjukkan perbezaan yang nyata antara roti canai yang disimpan pada suhu –10 °C hingga –12 °C selama 90 hari dan roti canai yang baru dibuat.

Abstract

Semi-cooked "roti canai" packed in high density polyethylene bags were stored at temperature ranges of –10 to –12, 2–4 and 9–11 °C for 90 days. Chemical, microbiological and sensory quality changes in the samples were studied on the 5th, 14th, 18th, 23rd, 28th, 36th, 60th and 90th day of storage. Microbiological analysis indicated that the three storage temperatures did not have much effect on the microbial count in the product. Sensory evaluation tests indicated that roti canai stored at –10 to –12 °C for 90 days were not significantly different from freshly prepared roti canai in terms of colour, texture, taste and overall acceptability.

Introduction

"Roti canai", a type of unleavened flat bread of Indian origin, is a popular food in the Indian and Malay community in Malaysia. It is usually sold by food outlets in a ready-to-eat form. Lately, various outlets have been selling chilled and frozen roti canai as well as roti canai dough.

In view of the increasing demand for chilled, frozen and convenient food products, there is potential for the large-scale manufacture and marketing of roti canai locally and abroad in suitable unit packs. Stored roti canai should have the characteristics of freshly prepared roti canai. Similarly, any mechanization process should result in a product similar to those made by traditional methods.

Very little information on roti canai is available in literature. Capati, another type of unleavened flat bread, is the nearest equivalent to roti canai. However, it differs from roti canai in terms of formulation and preparation.

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Kameshwara Rao et al. (1964) reported that capati packed in foil-polyethylene laminate (0.025 mm) could be kept for over 10 days without becoming mouldy at –5 °C to –10 °C and relative humidity of 70–90%. However, capati could only be kept for 5 days at 16 °C. Venkateswara Rao et al. (1986) found mould growth on capati packed in polyethylene pouch after 3 days of storage at atmospheric conditions of temperature (25–27 °C) and humidity (60–65%). However, for capati packed in waxed paper, the onset of mould growth was delayed by 12 h probably due to the loss of about 7% moisture. Spoilage of capati was due to attack of moulds that need moisture for growth and germination of spores.

This study was undertaken to assess the chemical, microbiological and sensory quality changes during low temperature storage of semi-cooked roti canai over 90 days. The storage temperatures used were –10 to –12, 2–4 and 9–11 °C as usually found in domestic refrigerators. The effects of consumer storage in domestic refrigerators on roti canai quality can thus be evaluated since in the home, chilled and frozen products are more susceptible to consumer abuse unlike in the manufacturing sector where strict temperature control and storage are carried out.

Materials and methods

Preparation and packaging

Roti canai was prepared using a standard formulation consisting of ingredients such as wheat flour, condensed milk, sugar, eggs, salt, cooking oil, ghee, margarine and water. The ingredients were mixed, shaped into round pieces and heated for 1 min on each side with a mixture of 4 parts of oil to 1 part of ghee. After cooling for 1 h at room temperature (27 °C), each piece of roti canai was packed in 255 mm x 170 mm high density polyethylene bags of 0.04 mm thickness and heat sealed.

Storage

Batches of 30 roti canai pieces were stored at temperatures of –10 to –12, 2–4 and 9–11 °C for 90 days.

Analysis and evaluations

Samples were taken from each storage temperature on the 5th, 14th, 18th, 23rd, 28th, 36th, 60th and 90th day of storage for chemical, microbiological and sensory evaluation. Proximate analysis was done on the fresh sample.

Chemical analysis Peroxide value of the stored samples (in duplicate) was determined according to the method of A.O.C.S. (1975) while proximate analysis on the fresh sample (in duplicate) was done according to Pearson (1976). Moisture content was determined throughout the storage period.

Microbiological analysis A piece of roti canai was taken from each storage temperature on each sampling day and left to thaw for 3 h at 4 °C. A 10 g sample was then weighed and homogenized with 90 mL Ringers solution using a stomacher. Serial dilutions were made and 1 mL volumes of appropriate decimal dilutions were pour-plated using total plate count agar (TPCA) and potato dextrose agar (PDA) to determine total viable count, and yeast and mould count respectively. Microbial colony was counted after 48 h of incubation at 37 °C for TPCA and 5 days at 25 °C for PDA (modification of ICMSF 1978). Water activity was determined at 23–25 °C with a Rotronic Hygroskop DT meter model CH-8040 Zurich.

Sensory evaluation The stored roti canai were evaluated organoleptically using freshly prepared samples as control. Each stored sample was thawed for 2 h at 26 °C and heated for 5 min on a heated metal plate with 1.5 mL of oil-ghee mixture (ratio of 4:1). The quality attributes assessed by 10 taste panelists were colour, texture, taste and overall acceptability. Sensory evaluation scores were described by using a nine-point hedonic rating scale ranging from 1 (dislike extremely) to 9 (like extremely) (Larmond 1977).

Statistical analysis The mean score of each quality attribute was used as a measure of product acceptance. A two-way analysis of variance (ANOVA) was conducted for all quality attributes of the four samples stored for 90 days to determine the significant difference between the treatments. The sources of variation shown to be significant by ANOVA were further tested using Least Significant Difference test to estimate which means were statistically different (Larmond 1977).

Results and discussion

Chemical changes

Peroxide value This value is usually used to assess the rate of lipid oxidation. Peroxide value (PV) is the reactive oxygen content expressed in milliequivalents of free iodine per kilogram of fat. The PV is determined by titrating the liberated iodine from potassium iodide with thiosulphate. Most of the samples stored at –10 to –12, 2–4 and 9–11 °C had PV below 10 meq/kg except for samples at 9–11 °C analysed on the 23rd and 28th day *(Figure 1)*. The PV were 10.61 and 11.25 meq/kg respectively. Fresh oils usually have PV well below 10 meq/kg (Egan et al. 1981). According to Augustine and Chong (1986), a PV greater than 10 meq/kg indicates that the fat has undergone a substantial degree of oxidation. The PV of sample stored at 9–11 °C indicated that the fat has undergone substantial oxidation and this may suggest that the storage temperature is not very suitable. However, the usefulness of the PV is limited to the initial stages of oxidation and the interpretation of results has to be done in relation to organoleptic assessment for rancidity which is discussed in the next section.

In the early stages of lipid oxidation, hydroperoxide formation has taken place in the product due to the oxidation of fatty acids. This can be seen from the sharp rise in PV by the 28th day of storage at all three storage temperatures. As lipid oxidation progressed, PV decreased after the 28th day probably due to decomposition and reaction of the unstable hydroperoxides with other materials such as protein and enzymes in the semi-cooked roti canai. It is likely that the enzymes in the flour have not denatured as the roti canai was only semi-cooked. After the 60th day, PV increased again probably

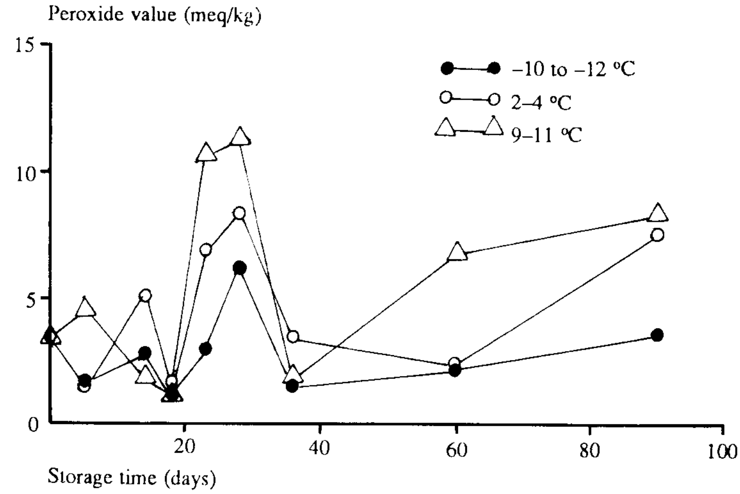

Figure 1. Peroxide value of roti canai during low temperature storage

due to further oxidation of fatty acids in another part of the chain taking place.

Proximate analysis Results showed that the freshly prepared roti canai had values *(Table 1)* fairly similar to those compiled by Tee et al. (1988). Fresh roti canai had a fat content of 8.96% derived from the ingredients such as condensed milk, eggs, oil, ghee and margarine.

Table 1. Proximate analysis of freshly prepared roti canai

Chemical composition	Value (%)
Moisture	29.14
Fat	8.96
Protein (N x 6.25)	6.97
Ash	1.23
Crude fibre	1.15

Moisture content Results obtained from the two storage studies (average) showed that the moisture content of samples stored at the three temperatures was in the range of 30.39–32.96% throughout the storage period *(Figure 2)*. This is because polyethylene is a good moisture barrier and resistant to temperatures as low as –20 °C (Flatman 1977; Oswin 1977).

Microbiological changes

Results of the microbiological analysis showed that the storage temperatures did not have much effect on the growth of microorganisms in the semi-cooked roti canai. The initial load of microorganisms was considered very low as the cooking process was sufficient to kill most of the microorganisms. However, some water condensation during storage and a suitable

Table 2. Microbiological changes of roti canai during storage

Storage time (days)	Total viable count (cfu/g)			Yeast & mould count (cfu/g)			Water activity at 23–25 °C		
	–10 to –12 °C	2–4 °C	9–11 °C	–10 to –12 °C	2–4 °C	9–11 °C	–10 to –12 °C	2–4 °C	9–11 °C
5	<3.0 x 10^2 (1.0 x 10)	6.1 x 10^2	<3.0 x 10^2 (1.0 x 10)	<1.0 x 10	<3.0 x 10^2 (5.0 x 10^0)	<1.0 x 10	0.97	0.97	0.97
14	<3.0 x 10^2 (5.0 x 10)	<3.0 x 10^2 (1.5 x 10)	<1.0 x 10	<1.0 x 10	<1.0 x 10	<1.0 x 10	0.97	0.97	0.97
18	<3.0 x 10^2 (5.0 x 10^0)	<3.0 x 10^2 (1.0 x 10)	<3.0 x 10^2 (5.0 x 10^0)	<1.0 x 10	<1.0 x 10	<1.0 x 10	0.97	0.97	0.97
23	<1.0 x 10	<3.0 x 10^2 (5.0 x 10^0)	8.5 x 10^3	<1.0 x 10	<1.0 x 10	<3.0 x 10^2 (5.0 x 10^0)	0.97	0.97	0.97
28	<3.0 x 10^2 (5.0 x 10^0)	<3.0 x 10^2 (5.0 x 10^0)	<3.0 x 10^2 (5.0 x 10^0)	<1.0 x 10	<1.0 x 10	<1.0 x 10	0.96	0.97	0.97
36	<1.0 x 10	<1.0 x 10	<1.0 x 10	<1.0 x 10	<1.0 x 10	<1.0 x 10	0.97	0.97	0.97
60	<3.0 x 10^2 (1.5 x 10)	<3.0 x 10^2 (2.5 x 10)	<3.0 x 10^2 (1.5 x 10)	<1.0 x 10	<1.0 x 10	<1.0 x 10	0.97	0.97	0.97
90	<3.0 x 10^2 (2.0 x 10)	<3.0 x 10^2 (2.5 x 10)	<3.0 x 10^2 (1.5 x 10)	<1.0 x 10	<1.0 x 10	<1.0 x 10	0.97	0.97	0.97
Fresh sample	<1.0 x 10			<1.0 x 10			0.96		

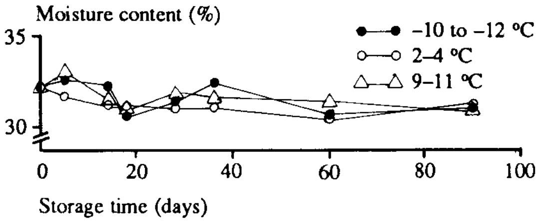

Figure 2. Moisture content of roti canai during low temperature storage

Table 3. Average scores of sensory evaluation of roti canai

Storage time (days)	Colour				Texture				Taste				Overall acceptability			
	Fresh sample	−10 to −12 °C	2–4 °C	9–11 °C	Fresh sample	−10 to −12 °C	2–4 °C	9–11 °C	Fresh sample	−10 to −12 °C	2–4 °C	9–11 °C	Fresh sample	−10 to −12 °C	2–4 °C	9–11 °C
0	7.1	–	–	–	7.0	–	–	–	6.6	–	–	–	6.8	–	–	–
5	6.8	6.5	6.1	6.8	6.6	6.7	6.1	6.5	6.9	6.0	6.5	6.9	6.8	6.2	6.2	6.6
14	5.8	6.2	6.0	6.3	5.8	5.9	6.0	5.6	5.4	5.9	6.3	6.1	5.4	5.8	5.7	6.2
18	6.5	6.6	6.4	7.0	6.6	6.2	6.0	6.2	7.0	6.4	6.8	6.5	6.8	6.1	6.6	6.4
23	6.3	6.7	6.4	6.8	6.6	5.9	5.9	5.7	6.7	6.2	6.4	6.3	6.9	6.4	6.5	6.2
28	5.5	5.8	5.8	6.5	5.3	6.4	5.9	5.6	5.8	6.0	6.5	5.8	5.7	5.8	6.5	5.9
36	6.1	6.6	6.0	5.6	6.7	6.2	6.0	5.2	6.8	6.8	6.3	5.7	6.8	6.3	5.9	5.2
60	6.6	6.6	6.1	6.5	6.6	6.3	6.1	6.4	6.5	6.3	5.9	5.6	6.1	6.3	5.8	5.6
90	6.3	6.1	5.9	5.7	6.5	6.2	5.6	4.9	6.4	6.3	5.8	5.2	6.5	6.4	5.7	5.0

Sensory evaluation scores were described by using a 9-point hedonic rating scale ranging from 1 (dislike extremely) to 9 (like extremely)

temperature might allow a small number of microorganisms which survived the cooking process to grow. The total viable count (TVC) was always <3.0 x 10^2 colony forming units per gram of sample (cfu/g) when semi-cooked roti canai were stored at −10 to −12 , 2–4 and 9–11 °C for 90 days *(Table 2)*. However, on the 5th day of storage at 2–4 °C and the 23rd day at 9–11 °C, TVC was 6.1 x 10^2 and 8.5 x 10^3 cfu/g respectively. However, these are still considered low and insignificant since TVC after the 5th and 23rd day did not show any increase. Counts of yeast and mould were negligible during the storage period at the three temperatures despite high (0.96–0.97) water activity (a_w). This shows that growth of microorganisms does not depend on a_w alone but rather on a combination of factors such as initial load and temperature.

Sensory evaluation

From the average scores for each quality attribute, quality attributes with scores ≥ 5.0 are taken as being acceptable to the panelists *(Table 3)*. All results were ≥ 5.0 except that for texture of roti canai stored for 90 days at 9–11 °C. However, this sample was still acceptable to the panelists in terms of overall acceptability. These results indicate that all samples were acceptable to the panelists in terms of colour, taste and overall acceptability throughout the storage period. Rancid taste was not detected for all samples. This is in concurrence with Egan et al. (1981) who reported that rancid taste often begins to be noticeable when PV is 20–40 meq/kg. Thus all stored samples (maximum PV was 11.25 meq/kg) were still acceptable on the 90th day of storage despite some fat oxidation taking place. This is probably due to the unpleasant organoleptic characteristics caused mainly by atmospheric oxidation that is accelerated by heat, light, moisture and trace metals. Since the samples were stored at low temperatures in the dark, the effects of oxidation and hence rancidity had been reduced.

Table 4. ANOVA for sensory evaluation of roti canai on the 90th day of storage

Sensory quality	Source of variation	df	SS	MS	F-value
Colour	Treatment	3	2.00	0.67	0.75
	Judge	9	18.00	2.00	
	Error	27	24.00	0.89	
	Total	39	44.00		
Texture	Treatment	3	15.00	5.00	7.50**
	Judge	9	27.40	3.04	
	Error	27	18.00	0.67	
	Total	39	60.40		
Taste	Treatment	3	9.08	3.03	3.12**
	Judge	9	25.53	2.84	
	Error	27	26.18	0.97	
	Total	39	60.78		
Overall acceptability	Treatment	3	14.60	4.87	5.62**
	Judge	9	25.60	2.84	
	Error	27	23.40	0.87	
	Total	39	63.60		

** Significant at $p < 0.01$

Table 5. Mean value of Least Significant Difference test of roti canai on the 90th day of storage

Sensory quality	Fresh sample	Semi-cooked samples stored at		
		–10 to –12 °C	2–4 °C	9–11 °C
Colour	6.3a	6.1a	5.9a	5.7a
Texture	6.5a	6.2a	5.6ab	4.9b
Taste	6.4a	6.3ab	5.8ab	5.2b
Overall acceptability	6.5a	6.4a	5.7ab	5.0b

*Means in the same row with the same letter are not significantly different ($p < 0.05$)

ANOVA done on the 90th day showed that there were significant differences in texture, taste and overall acceptability among the different treatments *(Table 4)*. However, no significant difference in colour was obtained as all samples were heated for the same duration.

On the 90th day of storage, sample stored at 9–11 °C was significantly different ($p < 0.05$) from the fresh sample in texture, taste and overall acceptability *(Table 5)*. The result of the least significant test and the PV indicate that 9–11 °C is not a suitable temperature for storing semi-cooked roti canai for 90 days. At home, frequent opening and closing of the domestic refrigerator will fluctuate and increase the temperatures resulting in the high probability of product deterioration in a short time. Thus, this storage temperature is not recommended for semi-cooked roti canai. Samples stored at –10 to –12 °C were most similar to fresh roti canai since there were no significant differences in colour, texture, taste and overall acceptability *(Table 5)*. Hence, semi-cooked roti canai can be kept for 90 days at –10 to –12 °C without becoming mouldy while retaining the sensory qualities of fresh roti canai. Since the sample stored at 2–4 °C showed no significant difference from either the fresh or the sample stored at 9–11 °C on the 90th day of storage, it is recommended that semi-cooked roti canai should not be kept for more than 23 days at 2–4 °C in the domestic refrigerator.

Conclusion

Semi-cooked roti canai stored at –10 to –12 °C for 90 days in high density polyethylene bags were most similar to fresh roti canai with respect to colour, texture, taste and overall acceptability. The sample retained the sensory qualities of fresh roti canai without becoming mouldy. Rancidity was not detected in stored samples, peroxide values of samples being less than 20 meq/kg. Microbiological analysis indicated that the three temperatures did not have much effect on the growth of microorganisms in the semi-cooked roti canai, microbial load generally being low (<3.0 x 10^2 cfu/g). For domestic refrigerators, storage at 9–11 °C is not recommended, whereas storage at 2–4 °C should not be more than 23 days.

Acknowledgements
Authors wish to thank Mr Chuah Yek Kin, Ms Noraini Ibrahim, Ms T. Nor Azizah T. Ibrahim and Ms Zaharah Ismail for their contribution to this project.

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Accepted for publication on 15 December 1990