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The Quality of Candle Nut (*Aleurites moluccana* (L.) Willd.) Stored under Controlled Atmosphere

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Abstract: The effects of carbon dioxide on fungal populations, lipid and free fatty acid (FFA) contents of shelled broken candle nut (*Aleurites moluccana* (L.) Willd.) were investigated together with moisture contents. As much as 300 g of shelled broken candle nut with initial moisture content of 5.4% were placed in a three-liter jar. CO_2 contents used were 10, 30, 50 and 70% in air, respectively. As control, air was incorporated into the jar instead of CO_2. The candle nuts were stored for 30, 60 and 90 days, respectively, at 25 – 28℃ and at relative humidity of 60% – 80%. Three replicates were used for each treatment and the control. The moisture contents were relatively constant during storage. The lowest moisture content (5.3% w. w) occurred at 70% CO_2 content after 90 days of storage, while the highest moisture content (5.5% w. w) was in the control after 60 days of storage. Total fungal population decreased with the increase of CO_2 contents. After 90 days of storage, the lowest total fungal population (6.7×10 cfu/g w. w) occurred at 70% CO_2 content, but it was not significantly different with that of 50% CO_2 content (4.5×10^2 cfu/g w. w) and 30% CO_2 content (1.2×10^5 cfu/g w. w). Although the lowest lipid content (46.38% w. w) occurred at 70% CO_2 content after 90 days of storage, it was not significantly different with that of 50% CO_2 content (51.20% w. w). FFA contents increased with the increase of CO_2 content. The lowest FFA content (2.94% w. w) occurred at 70% CO_2 content after 90 days of storage and it was not significantly different with that of 50% CO_2 content (3.93% w. w). Storage of shelled broken candle nuts up to 90 days can be carried out using 50% CO_2 content.

Key words: candle nuts, controlled atmosphere, quality

Introduction

In Indonesia candle nut is used especially for seasoning. The oil of candle nut is servesed among others for preparing soap, cosmetics, and medicines. Candle nut is exported in the form of rolling seeds, sound shelled seeds, and broken shelled seeds. Shipping in the form of rolling seeds needs big transportation space and reduces the capacity of exported candle nut, consequently shipping in the form of shelled seeds will be a good solution to overcome this limitation. Nevertheless, shelling of rolling seeds has a constraint, because the percentage of sound shelled seeds is low. Besides, the quality of shelled seeds could be easily reduced, because its lipid content is high and it is easily infected by fungi during storage. Dominant fungi infecting 19 candle nut samples collected in Bogor (West Java) and Yogyakarta (Central Java) were *Aspergillus flavus*, *A. niger*, *A. tamarii*, *A. wentii*, *Eurotium chevalieri*, *E. rubrum*, and *Penicillium citrinum*[1]. Carbon dioxide is used for insect control, but no study has been conducted on the effect of CO_2 on the quality of candle nut. The objective of this study was to investigate the change of broken shelled seed candle nut quality (moisture contents, fungal population, lipid and free fatty acid contents) stored under controlled atmosphere using CO_2.

Materials and Method

Preparation of Broken Shelled Candle Nut

Broken shelled candle nut seeds were derived from candle nut fruits. The fruit were collected from Camba district, Maros regency, South Sulawesi Province. Broken shelled seeds 2 4 were prepared for the experiment. The seeds were fumigated using phosphine (2 g/ton) for 7 days for disinsectisation all insect stadia that may exist.

CO_2 Treatment and Storage of Candle Nut Seeds

Twenty four hours after phosphine fumigation, 300 g broken shelled seeds (moisture contents 5.0 0.5%) were packed in a sac made from plastic net. They were then placed in a

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3litre glass jar which could be vacuumed and filled with atmospere with different CO_2 contents in air. The sac containing the seeds was supported by a perforated plastic container. CO_2 contents used were 10, 30, 50 and 70%, respectively. As control, air was incorporated into the jar instead of CO_2. The seeds were stored for 30, 60 and 90 days, respectively, at 25, 28℃ and 60, 80% rh.. Three replicates were used for each treatment and the control.

Sampling and Obtaining Working Sample

After the treatment, the seeds from each jar were stored subsequently for 30, 60, 90 days, respectively. Samples were taken after the different storage periods, mixed thoroughly, divided twice to obtain working samples for determination of moisture content, fungal population, lipid and free fatty acid content, and as a reserve sample.

Determination of Nut Quality

Moisture content, lipid and free fatty acid contents were determined based on BSI [2] and AOAC[3], respectively. Fungal population was determined based on a serial dilution method followed by pour plate method on Dichloran 18% Glycerol Agar [4]. The data were analyzed using Completely Randomized Design with one factor. The factor consisted of five CO_2 contents (including the control).

Results and Discussion

The Effect of CO_2 on Moisture Content

At the beginning of storage, the moisture contents of candle nuts in the control were not significantly different from those treated with CO_2 at 10%, 30%, 50% and 70% contents in air, respectively. The same results were obtained with the moisture contents of candle nuts after 30, 60 and 90 days of storage (Table 1). The moisture contents were still higher than those determined by the Indonesian National Standar (*Standar Nasional Indonesia* or SNI) (BSN)[5], e. g 5% w. b.

Although based on the analysis of variance, CO_2 contents did not result in any significant differences of the moisture contents of treated candle nuts. The moisture contents were relatively similar and constant during storage. Based on their averages, moisture contents decreased after 30 days of storage, increased again slightly after 60 days and decreased again slightly after 90 days of storage. The moisture contents were always in equilibrium with the relative humidity of the storage.

The Effect of CO_2 on Fungal Population

After 90 days of storage, 13 fungal species and one unidentified isolate were isolated from from the candle nuts. The 13 fungal species were *Aspergillus candidus*, *A. flavus*, *A. niger*, *A. penicillioides*, *A. wentii*, *Cladosporium cladosporioides*, *Eurotium chevalieri*, *E. repens*, *Hyphopichia burtonii*, *Penicillium citrinum*, *P. rugulosum*, *Syncephalastrum racemosum* and *Wallemia sebi*. The dominant species were *Aspergillus*, *Eurotium*, *Penicillium*, and *Hyphopichia*.

In tropical regions, the most spoilage fungi in storage were *Aspergillus* and *Eurotium*, while the role of *Penicillium* was less than the two previous genera[6].

Fungal population decreased with the increase of CO_2 contents (Table 2). It was presumably due to the decrease of O_2 contents. In general, fungi are aerob obligate organisms[7]. Aerob fungi need O_2 for their growth. CO_2 at 20% content in air started to inhibit mycelia, conidiation (sporulation) and conidial germination of *A. flavus*[8]. The four parameters were inhibited with the increase of CO_2 content.

Total fungal populations were reduced significantly at different CO_2 contents after 30, 60 and 90 days of storage, respectively. Fungal populations started to become inhibited by CO_2 at 10% contents, but they were inhibited significantly at 30% CO_2. The highest increase of total fungal populations occurred in the control (1.8×10^2 cfu/g w. b.) before storage. They increased to 1.4×10^6 cfu/g w. b. after 90 days of storage. Total fungal populations in the control were very significantly different from those treated with CO_2 at 10, 30, 50 and 70% contents.

The Effect of CO_2 on Lipid Content

In general, lipid contents decreased with the increase of CO_2 contents after 90 days of storage (Table 3). The ranges of lipid contents before storage and 90 days after storage were 58.08% – 58.51% w. b. and 46.38% – 55.37% w. b., respectively. 70% CO_2 content caused the highest decrease of lipid contents, e. g. the contents before storage and 90 days after storage were 58.48% and 46.38% w. b., respectively. After 90 days of storage, lipid contents at 70% CO_2 content were significantly different from those at 10 and 30% CO_2 contents. But they were not significantly different from

those at 50% CO_2 content and the control.

Fungi will accelerate the degradation of lipid during storage[7]. *Aspergillus* and *Penicillium* are capable to degrade lipid into free fatty acid and glycerol by lipase.

The Effect of CO_2 on Free Fatty Acid Content

FFA content increased with the increase of storage duration (Table 4). After 90 days of storage, the highest and the lowest FFA contents occurred in the control (7.43% w. b.) and at 70% CO_2 content (2.94% w. b.), respectively. FFA in the control (7.43% w. b.) was not significantly different compared with FFAs on nuts stored at atmospheres with 10% (6.58% w. b.) and 30% (5.73% w. b.) content of CO_2 in air. The content of FFA at 70% CO_2 (2.94% w. b.) content was not significantly different from the values at 50% CO_2 (3.93% w. b.)

BSN determined the maximum FFA content of candle nuts to be 5%[5]. Candle nuts treated with CO_2 at 50 and 70% contents in air were accepted to be stored, because their FFA contents were 3.93 and 2.94% w. b., respectively.

Conclusions

CO_2 contents did not cause any significant effect on the moisture contents of candle nuts during storage.

Thirteen fungal species and one unidentified isolate have been isolated from candle nuts during storage. The dominant species were *Aspergillus*, *Eurotium*, *Penicillium* and *Hyphopichia*. After 90 days of storage, the lowest total fungal populations occurred at 70% CO_2 content, but they were not significantly different with those of 30 and 50% CO_2 contents.

The lowest lipid contents occurred at 70% CO_2 content after 90 days of storage, but they were not significantly different with those of 50% CO_2 content. FFA contents increased with the increase of CO_2 contents. After 90 days of storage, the lowest FFA content was found in samples which had been stored at 70% CO_2 content in air. It was not significantly different with that at 50% CO_2 content.

Storage of shelled broken candle nut up to 90 days can be carried out using 50% CO_2 content.

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Table 1. The effect of CO_2 contents on the moisture contents of candle nut during storage

CO_2 content (%)	Moisture content (% w. b.)			
	Duration of storage (day)			
	0	30	60	90
Control	5.44 a	5.43 b	5.54 c	5.36 d
10	5.43 a	5.41 b	5.52 c	5.34 d
30	5.40 a	5.38 b	5.51 c	5.33 d
50	5.43 a	5.39 b	5.50 c	5.32 d
70	5.41 a	5.37 b	5.47 c	5.31 d

Numbers followed by the same letter in the same column do not differ significantly according to Duncan's Multiple Range Test at 95% confidence level

Table 2. The effect of CO_2 contents on the total fungal population of candle nuts during storage

CO_2 content (%)	Total fungal population (cfu/g w. b.)			
	Duration of storage (day)			
	0	30	60	90
Control	180 a	1007 b	496 400 d	1 402 307 f
10	147 a	330 c	226 017 de	956 500 g
30	170 a	147 c	2 647 e	122 150 h
50	253 a	43 c	83 e	447 h
70	236 a	37 c	77 e	67 h

Numbers followed by the same letter in the same column do not differ significantly according to Duncan's Multiple Range Test at 95% confidence level

Table 3. The effect of CO_2 contents on the lipid content of candle nuts during storage

CO_2 content (%)	Lipid content (% w. b.)			
	Duration of storage (day)			
	0	30	60	90
Control	58.51 a	51.44 b	51.29 cd	49.43 ef
10	58.39 a	51.60 b	54.64 cd	54.17 e
30	58.08 a	50.65 b	55.79 c	55.37 e
50	58.27 a	51.42 b	53.63 cd	51.20 ef
70	58.48 a	51.23 b	49.53 d	46.38 f

Numbers followed by the same letter in the same column do not differ significantly according to Duncan's Multiple Range Test at 95% confidence level

Table 4. The effect of CO_2 contents on the free fatty acid content of candle nuts during storage

CO_2 content (%)	Free fatty acid content (% w. b.)			
	Duration of storage (day)			
	0	30	60	90
Control	1.78 a	2.85 b	7.30 c	7.43 h
10	1.84 a	2.86 b	6.26 d	6.58 h
30	1.83 a	2.22 b	4.78 e	5.73 hij
50	1.51 a	2.18 b	3.51 f	3.93 ij
70	1.52 a	2.02 b	2.89 g	2.94 j

Numbers followed by the same letter in the same column do not differ significantly according to Duncan's Multiple Range Test at 95% confidence level

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