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Effect of modified atmosphere storage on the shelf life and quality of black pepper and turmeric

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Abstract

Modified atmosphere packaging and storage of black pepper (var. Panniyur I) and turmeric (var. Prathiba) were studied for a period of 16 months under ambient storage conditions. Whole dry samples of black pepper and turmeric were packaged in three layered metalized polyester covers (12 μ polyester + 12 μ metalized polyester + 80 μ LDPE) under three modified storage atmospheres *viz*. 100% vacuum, 100% N_2, 90% N_2 + 10% CO_2 and the control samples were stored in small size jute gunny bags. Results indicated that maximum retention of quality in terms of its essential oil and oleoresin contents of black pepper and turmeric was obtained when stored under nitrogen packaging (100% N_2), followed by vacuum packaged (100% vacuum) and modified atmosphere storage of 90% N_2 + 10% CO_2. The essential oil content of stored black pepper reduced from 2.42% to 2.22% (dry weight basis, dwb) in all the three modified atmosphere storage with a loss of 8.26% while control recorded a loss of 16.53% during storage. The oleoresin content decreased from 7.79% to 7.44%, 7.38% and 7.32% in case of black pepper stored in 100% N_2 packaged, 100% vacuum packaged and 90% N_2 + 10% CO_2 packaged storage atmospheres. The quality loss for turmeric in terms of essential oil, oleoresin and curcumin content at the end of storage, when packaged in 100% N_2 atmosphere were 36.60%, 16.12% and 9.48%, respectively while the corresponding reduction in control samples were 40.49%, 20.27% and 19.39%.

Keywords: black pepper, modified atmospheric storage, quality, shelf life, turmeric

Introduction

Black pepper and turmeric are two important spices used as condiments and these spices are known for their curative medicinal properties. Black pepper is either used directly as spice or it serves as a raw material for the preparation of its value added derivatives namely essential oil, oleoresin, curry powder *etc*. Indian pepper, commonly known as "Malabar pepper" is considered to be the best in the world for its excellent aroma, flavour and pungency (Ravindran *et al*. 2000). Turmeric is used in many culinary preparations to add flavour and colour

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to foodstuffs and is the principle ingredient of curry powder.

Apart from their use as spice and flavouring substance, black pepper and turmeric serve as drugs in the Indian and Chinese systems of medicine. As a drug, black pepper increases the digestive power, cures cold, cough, dyspnoea, diseases of the throat, intermittent fever, colic, dysentery, worms and piles; improves appetite, useful in tooth ache, relieves pain in liver and muscle, inflammation, leucoderma and epileptic fits (Vijayan & Thampuran 2000). Turmeric has been used throughout Asia, to treat fevers, stomach problems, allergies, diarrhoea, chronic cough, heartburn, wind, bloating, colic, bronchial asthma, flatulence, jaundice and other liver ailments. Externally, it is used for reducing inflammation and swelling due to sprains, cuts and bruises (Satyajit & Nahar 2007).

Spices are hygroscopic in nature and absorb moisture from the atmosphere, resulting in softening and caking of powdered product. During storage of spices, loss in volatile oil content or oxidation of some of the easily volatile aromatic compounds result in loss of aroma and flavour. Spices are also prone to spoilage during storage due to insect infestation, which is further accelerated due to high humidity, heat and oxygen. In high humidity condition of 65% and above, moisture absorption occurs and beyond a certain level, spoilage due to microbial growth sets in. In order to maintain the quality of the spices during storage, handling, transportation and distribution, the packaging materials used are selected keeping in mind both the functional and the marketing requirements of the spice (Sacharow & Griffin 1980). The traditional method for bulk packaging of whole spices is to use gunny or jute bags provided with or without polyethylene liner. Sometimes double gunny bags are also used. The retail packaging is generally done in consumer packs and packaging materials used are polyethylene, poly propylene or laminated metalized covers etc. In order to overcome the difficulties in handling and storage of whole spices or spice powders, spice extracts like spice essential oils and oleoresins are gaining importance in food processing industry as these extracts have consistency of flavour, longer shelf life, easier storage and handling, not infected by bacterial contamination and complete release of flavour during cooking.

Modified Atmosphere Packaging (MAP) is an improved method of storage under which the normal composition of air is changed or modified. Generally, during the MAP storage, there is a reduction in the oxygen level of the air and an increase in the level of carbon dioxide and nitrogen to slow down the respiration rate, reduce microbiological growth and retard enzymatic spoilage for the purpose of extending shelf life (Young *et al.*, 1988). MAP is mainly used for the retail distribution of small pre-packed units and the concentration of CO_2 used in these products is generally much higher (Smith *et al.* 1990). Literature on MAP for storage of spices are very scanty. Hence the present work was taken up to study the shelf life of black pepper and turmeric under modified atmosphere storage and to assess the quality changes that occur during storage.

Materials and methods

Black pepper (var. Panniyur I) and dry turmeric (var. IISR-Prathiba) were collected from ICAR-Indian Institute of Spices Research, Experimental Farm, Peruvannamuzhi. Approximately about 100 g of whole dry black pepper and turmeric samples each were packed in three layered metalized polyester covers (12 μ polyester + 12 μ metalized polyester + 80 μ LDPE) and stored in three modified storage atmospheres *viz.* vacuum-packaging (100% vacuum), modified gas mixture composed of 100% N_2 and 90% N_2 + 10% CO_2 gas mixture. The modified storage atmospheres were produced using a gas mixer (PBI-Dansensor model MAP mix 9000-3/150, Denmark). An electronic vacuum packer (Reepack, RV-50, Denmark) was used to flush the gas mixtures and seal the pouches. The pouches were made of aluminium metalized covers of size 210 × 150 mm and the control sample was packed in jute gunny bags (150 × 100 mm). The experiments were conducted during 2007-08 and all the samples were kept under ambient conditions with temperature varying from 28 to 32.4^{o}C and RH varying from 70 to 90% during the storage period of 16 months. The samples were opened for subsequent analysis after 2, 4, 6, 12 and 16 months of storage and quality changes during storage was studied.

The samples were analysed for secondary metabolites like essential oil, oleoresin, piperine in black pepper and curcumin in turmeric. Essential oil, oleoresin and moisture content were estimated as per the methods described by ASTA (1968). Piperine was estimated by HPLC method as reported by Wood *et al.* (1988). Curcumin was quantitatively extracted by refluxing the material in alcohol and estimated spectrophotometrically at 425 nm as described by Sadasivam & Manickam (2008). Essential oil constituents of black pepper were separated in a Perkin Elmer Autosystem gas chromatograph (Total Chrom Autosystem XL GC IPM 1204-WS0084 software (oven programme: 70–210 ^oC @ 5 $^oC/ min^{-1}$., column- OV-17, detector-FID at 300 ^oC and injection port at 200^oC). The compounds were identified using Sigma standards.

A two factor completely randomized block design was followed to determine the effects of storage atmospheres and storage period on the keeping quality of the whole dried black pepper and turmeric. All the experiments were replicated thrice. AGRES (Version 7.01, Pascal International software solutions) statistical software was used to analyse the data.

Results and discussion

The initial moisture content of the stored black pepper sample was 9.0% and increased to 10.8% during storage in gunny bags control. Among the various storage atmospheres, black pepper stored in 100% vacuum, 100% N_2 and 90% N_2 + 10% CO_2 had a final moisture content of 9.8%, 9.8% and 9.9%, respectively. In 100% N_2 and 90% N_2 + 10% CO_2 storage atmospheres, moisture content reached 9.8% and 9.9% respectively after 6 months of storage which remained unchanged till 16 months. In 100 vacuum and control, moisture content reached 9.5% and 10.2% after 6 months of storage which further increased to 9.8% and 10.8% after 16 months. The variation in moisture content was significant during the storage period and among the packaging atmospheres. However, the rise in moisture content was within the safe moisture limits of less than 11% (Jayashree 2005) in all the modified atmosphere storage of black pepper.

Shelf life / storage studies of whole black pepper was carried out at Indian Institute of Packaging using different packaging materials including traditional cotton and jute bags. The results of the studies indicated that under accelerated ageing conditions of storage like high relative humidity, the conventional jute and cotton bags offer a low shelf-life and there was loss of aroma, as well as moisture loss / gain beyond the acceptable limits. At the test conditions, where the relative humidity was high, the moisture absorption was very rapid leading to fungus growth and deterioration of the product. In these packs, the shelf-life at normal conditions was 3 to 4 weeks (IIPT 2011). Effect of storage structures on the quality of black pepper has been reported earlier. Black pepper stored in storage structures such as bamboo basket, pot and tin for one year under laboratory conditions showed the presence of *Aspergillus flavus, Aspergillus fumigatus, Aspergillus niger* and *Aspergillus japonicus*. Some fungal isolates produced mycotoxins including aflatoxin B_1, gliotoxin, ochratoxin A, patulin etc. The highest weight loss and highest content of total phenols, total nitrogen and free fatty acids were recorded for seeds stored in bamboo basket. Starch content and reducing sugars also declined during storage (Giridhar & Reddy 2002).

In our studies, the initial moisture content of the stored turmeric sample was 8.1% which increased to 10.2% after 6 months of storage which further increased to 10.8% after 16 months. In sample stored in 100% vacuum and 100% nitrogen atmosphere, the moisture content reached 9.6% and 9.2% after 6 months and storage which further rose to 9.9% and 9.7%, respectively, after 16 months while the sample stored in 90% N_2 + 10% CO_2 moisture content increased to 9.3% after 6 months which further increased to 9.6% after 16 months. The variation in moisture content was significant during the storage period but under modified atmosphere packaging the rise in moisture content was within the permissible limits of less than 10%. Packiyasothy *et al*. (1983) reported that moisture content of powdered black pepper increased from 8 to about 9–14% during storage in various thickness of LDPE, HDPE, aluminium foil and lacquered tinned cans. The study confirmed that LDPE and HDPE are poor barriers for moisture.

The initial essential oil content of the black pepper sample was 2.42% which reduced to 2.22% in all the three modified atmospheric storages and

2.02% in the control (16.53% loss) after 16 months of storage (Table 1). The initial essential oil content of turmeric sample was 4.89% which reduced significantly in all the four storage atmospheres (Table 1). It reduced to 2.91% in the control (40.49% reduction from the initial value). But, in case of all other packaging atmospheres, the final essential oil content was 3.10% corresponding to a decrease of 36.61% of the initial value. Goyal & Korla (1993) reported a decrease in essential oil content for both cured and uncured turmeric rhizomes during storage with a maximum loss of 27.5% in essential oil content in cured turmeric for the cultivar 'EM-321' at the end of storage for 12 months. Packiyasothy *et al*. (1983) reported that the essential oil content of powdered black pepper (2%) declined markedly (more than 80%) when stored under different thickness of LDPE and HDPE packaging materials but remained constant (2%) in aluminium foil laminates and in tinned can.

The initial oleoresin content of black pepper was 7.79% which reduced to 7.44% at the end of 16 months storage (4.49% loss) when stored in nitrogen atmosphere followed by vacuum packaged black pepper (5.26% loss) followed by control sample (6.80% loss) (Table 2). Both storage atmosphere and storage period significantly influenced the oleoresin content. In turmeric, the loss in oleoresin content was 20.27% in control, 16.12% in nitrogen atmosphere followed by 16.65% in case of 100% vacuum packaged atmosphere during the storage period of 16 months. There was significant decrease in oleoresin content in all the storage atmospheres by the second month of storage (Table 3). Goyal & Korla (1993) reported a reduction in oleoresin content by 24.2% during storage of cured turmeric rhizomes (cultivar: EM-321) in unsealed polythene cover for 12 months when stored at room temperature (10–35 °C) and relative humidity of 23–95%.

Table 1. Variation in essential oil content (% dry weight basis, dwb) of black pepper and turmeric stored in various atmospheres

Storage atmosphere		Storage period (months)					
		0	2	4	6	12	16
		Black pepper					
Vacuum		2.42	2.42	2.42	2.35	2.31	2.22
100% N_2		2.42	2.42	2.42	2.35	2.30	2.22
90% N_2 + 10% CO_2		2.42	2.42	2.35	2.33	2.29	2.22
Jute gunny bag (Control)		2.42	2.40	2.35	2.33	2.23	2.02
CD at 5%							
Storage atmosphere (SA)	NS						
Storage period (PS)	0.10						
SA × PS	0.17						
		Turmeric					
Vacuum		4.89	4.84	4.51	3.98	3.25	3.10
100% N_2		4.89	4.82	4.82	4.41	3.21	3.10
90% N_2 + 10% CO_2		4.89	4.81	4.60	4.41	3.19	3.10
Jute gunny bag (Control)		4.89	4.05	3.55	3.37	3.08	2.91
CD at 5%							
Storage atmosphere (SA)	0.13						
Storage period (PS)	0.13						
SA × PS	0.20						

Table 2. Variation in oleoresin content (% dwb) of black pepper and turmeric stored in various atmospheres

Storage atmosphere		Storage period (months)					
		0	2	4	6	12	16
		Black pepper					
Vacuum		7.79	7.61	7.55	7.42	7.40	7.38
100% N_2		7.79	7.62	7.58	7.50	7.45	7.44
90% N_2 + 10% CO_2		7.79	7.60	7.52	7.40	7.38	7.32
Jute gunny bag (Control)		7.79	7.52	7.50	7.34	7.28	7.26
CD at 5%							
Storage atmosphere (SA)	0.16						
Storage period (PS)	0.34						
SA x PS	0.44						
		Turmeric					
Vacuum		16.87	15.67	15.25	15.21	14.32	14.06
100% N_2		16.87	15.77	15.27	15.25	14.47	14.15
90% N_2 + 10% CO_2		16.87	15.52	15.25	15.16	14.30	14.05
Jute gunny bag (Control)		16.87	14.82	14.97	13.71	13.97	13.45
CD at 5%							
Storage atmosphere (SA)	0.76						
Storage period (PS)	0.74						
SA x PS	1.17						

In black pepper, the piperine content at the beginning of storage was 2.53%. The final piperine content in control sample was 2.25% with a loss of 11.07% and the loss in other storage atmospheres at the end of storage period was 7.12%, 4.35% and 8.30% corresponding to 100% vacuum, 100% N_2 and 90% N_2 + 10% CO_2 atmospheres, respectively. In all the storage atmospheres, the reduction in piperine content was found significant by the end of storage period. However, modified atmosphere packaging like 100% N_2 atmosphere and 100% vacuum helped in the better retention of quality for a period of 16 months of storage. Packiyasothy *et al*. (1983) reported that LDPE cover of 25 µm only showed a significant decrease when stored at room temperature (10–35 °C) and relative humidity of 23–95%. Narasimhan *et al*. (1990) reported that black pepper powder (60 mesh) when stored in consumer unit packs of 100 g capacity in low density polyethylene (LDPE) films of 100, 300, and 500 gauge at 27 °C and 65% RH showed no loss of piperine up to the end of the study for 80 days of storage.

The initial curcumin content of turmeric was 6.96% which reduced significantly after 16 months of storage. Turmeric stored under 100% N_2 atmosphere recorded the maximum retention of curcumin (6.30%) with a loss of 9.48% at the end of storage period (Table 3). Curcumin content was lowest in the control samples (5.61%) with a maximum loss of 19.39% after 16 months of storage. However, both modified storage atmosphere packaging and storage period had significant influence on the final curcumin content of stored turmeric. Goyal & Korla (1993) reported a gradual decrease in curcumin content during storage of turmeric for a period up to 10 months. Thereafter, there was no or negligible reduction in curcumin content. The maximum loss in curcumin content was 23.4% after one year of storage in cured rhizomes of the cultivar EM-321 when stored at room temperature (10–

Table 3. Variation in curcumin content (% dwb) of turmeric rhizomes stored in various atmospheres

Storage atmosphere		Storage period (months)					
		0	2	4	6	12	16
Vacuum		6.96	6.46	6.42	6.38	6.30	6.23
100% N_2		6.96	6.46	6.41	6.34	6.32	6.30
90% N_2 + 10% CO_2		6.96	6.41	6.32	6.30	6.18	6.13
Jute gunny bag (Control)		6.96	6.36	6.25	6.17	6.03	5.61
CD at 5%							
Storage atmosphere (SA)	0.48						
Storage period (PS)	0.58						
SA x PS	0.90						

35 °C) with a relative humidity of 23–95%. Bambirra *et al*. (2002) reported that good quality turmeric was obtained by cooking turmeric in plain water and no significant change in curcuminoid pigment was observed during storage for 60 days.

The constituents of essential oil of black pepper were studied initially and the important constituents present in the essential oil were pinene (14.09%), sabinene + myrcene (32.10%), limonene (27.89%) and β caryophyllene (16.84%). After 16 months of storage, there was significant reduction in pinene content in all the four storage atmospheres. However, the control sample recorded the maximum loss of 12.70%. Maximum retention of pinene (13.24%) was recorded in 100% N_2 packaging followed by 100% vacuum packaged (12.95%) and the loss accounted to 6.03% and 8.09%, respectively. The retention of sabinene + myrcene, limonene and β caryophyllene were also higher in 100% N_2 packaging with a loss of 3.77%, 1.61% and 18.4%, respectively during storage (Table 4). Packiyasothy *et al*. (1983) reported greater loss of monoterpene hydrocarbons and lower rate loss of sesquiterpene hydrocarbons during storage of black pepper powder in LDPE, HDPE, aluminium foil laminates and tinned cans after 6 months of storage.

In conclusion, the results of the study indicated that at the end of storage period of 16 months, black pepper and turmeric when stored under modified atmospheric packaging of 100% nitrogen followed by 100% vacuum and 90% N_2 + 10% CO_2 had maximum retention of quality in terms of its essential oil and oleoresin contents.

Table 4. Composition of essential oil constituents (% dwb) of black pepper (Panniyur-I) as influenced by various modified atmospheres

Storage atmosphere	Pinene (%)	Sabinene + Myrcene (%)	Limonene (%)	β-Caryophyllene (%)
	Initial content,	(0^{th} day)		
Dry pepper (initial)	14.09	32.10	27.89	16.84
	Final content,	(16^{th} month)		
Vacuum	12.95	28.49	26.575	13.70
100% N_2	13.24	30.89	27.44	13.74
90% N_2 + 10% CO_2	12.32	29.76	26.38	13.63
Jute gunny bag (Control)	12.30	28.34	25.91	13.00
CD at 5%	0.35	0.43	0.15	0.34

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