

DETERIORATION OF SAFFLOWER AND SESAME SEEDS IN STORAGE BY FUNGI UNDER DIFFERENT TEMPERATURES

BY

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Freshly harvested and six months old safflower and sesame seeds were stored in laboratory under 80% and 90% RH at 10°, 20° and 30°C for three months and moisture content, germinability, fungal infection, organic dry matter, oil content of the seeds and FAV of oil were studied at monthly intervals. Moisture content was found to be more at higher relative humidity and lower temperature. Percentage of infection by storage fungi was highest at 90% RH and 20°C whereas maximum loss in oil content, germinability, organic dry matter and highest increase in FAV was observed under higher temperature and higher RH.

INTRODUCTION

In India, loss off agricultural produce by fungal deterioration in storage is very high. Extent of deterioration is known to be greatly influenced by seed moisture and surrounding temperature among other factors. Sesame and safflower are extensively cultivated in West Bengal and their oils are used both in industry and for edible purpose. In natural storage, germinability of these seeds were adversely affected and oil showed physicochemical changes (Unpubl. data). The present work was undertaken to determine the effect of combinations of different temperatures, relative humidities and storage periods on the extent of deterioration of seeds in storage and to establish a safe combination that would prevent accelerated biodeterioration of the seeds.

MATERIALS AND METHODS

Sesame (*Sesamum indicum* L.) and safflower (*Carthamus tinctorius* L.) seeds were collected after harvest (April, 1981) and stored (80 kg/bag) under

normal conditions upto one year. Freshly harvested (1st lot) and six month old (2nd lot ; Oct, 1981) seeds were taken out from the gunny bags and placed in well ventilated polyethylene bags (1 kg/bag). These bags were placed in dessicators under 80% and 90% relative humidities (RH) and stored at 10°, 20° and 30°C for 90 days. Saturated solutions of ammonium sulphate and potassium nitrate were used to maintain 80% and 90% RH respectively (Wink and Spears, 1950). Seed samples were taken out from each dessicator at intervals of 30 days and different parameters of seed health were studied.

Seed moisture was determined by oven drying of sesame seeds at 80°C and safflower at 103°C for 72 hours (USDA, 1959) and expressed as percentage on dry weight basis.

Germinability was determined by placing 200 surface sterilized (treated with 0.1% HgCl_2) seeds on sterile moist filter paper (ISTA, 1966) and incubating them at $30 \pm 2^\circ\text{C}$ for 7 days. Only seedlings with well developed root and shoot were taken to be germinated.

Seed infection by field and storage fungi was determined from 200 surface disinfected (0.1% HgCl_2) seeds placed on malt agar (2% malt) and salt malt agar (10% NaCl) respectively following Nandi and Fries (1976)

Organic matter was estimated on dry weight basis following Ward and Diener (1961).

Oil was extracted by petroleum ether (b. p. 40-60°C) in Soxhlet extractor for 6 hours (Meara, 1955) and oil content was estimated as percentage on dry weight basis. Fat acidity value (FAV) was determined following Meara (1955).

RESULTS

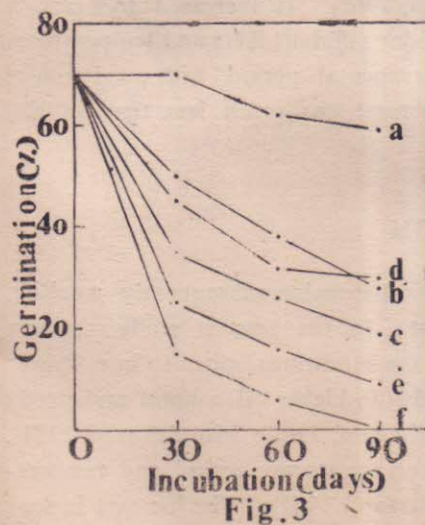
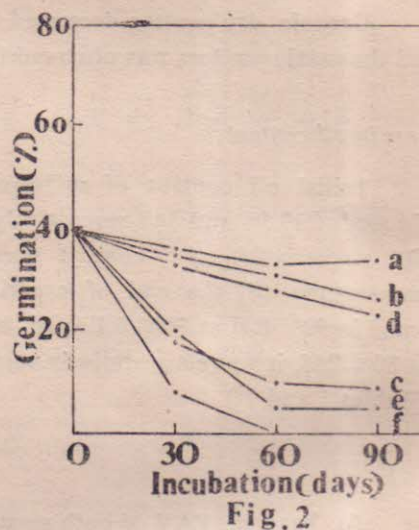
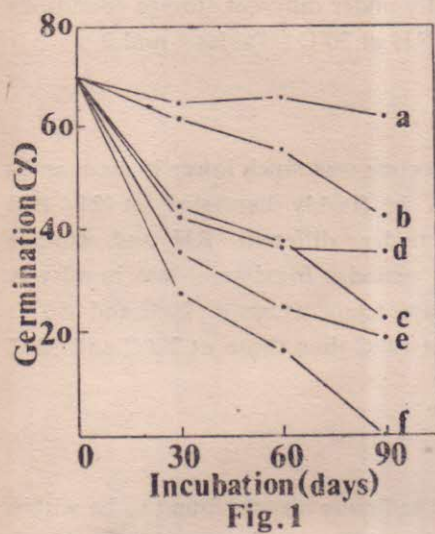
Seed moisture

Initial seed moisture was higher in the 2nd lot than in the 1st lot and moisture content of safflower seeds were always higher than that of sesame store under identical conditions. In both seed lots moisture level increased under most of the experimental conditions except at 30°C and 80% RH where it remained more or less unchanged. At higher RH and lower temperature such increase was more pronounced. Increase was higher at 10°C than at 20°

or 30°C under both RH. Rate of increase was always highest after first 30 days (Tables 1 and 2).

Germinability

Seeds of safflower showed 70% germination at harvest but decreased sharply to 40% after 6 months (Fig. 3). In both seeds it decreased with further storage under different conditions (Figs. 1-3). In all seeds loss of germinability was minimum at 80% RH and 10°C. Germinability was retained better at lower temperature and lower seed moisture.



Effect of different RH, temperatures and storage periods on germinability of safflower and sesame seeds : Fig. 1—Safflower fresh seeds, Fig. 2—Safflower 6 months old seeds, Fig. 3—Sesame 6 months old seeds.

a=80% RH and 10°C ; b=80% RH and 20°C ;
c=80% RH and 30°C ; d=90% RH and 10°C ;
e=90% RH and 20°C ; f=90% RH and 30°C ;

Fungal infection

At harvest, both safflower and sesame seeds were found to be infected by field fungi which decreased gradually and reached almost zero in the 2nd lot. On the other hand, storage fungi gradually increased in both seeds with longer storage. Fungal population was higher at 20°C than at 30°C in both RHs, but least at 10°C (Tables 1 and 2).

Organic dry matter

Organic dry matter decreased gradually under different storage conditions and the maximum loss was observed in 90% RH at 30°C (Tables 1 and 2).

Loss in oil content

Initial oil content of safflower and sesame was much lower in six months old seeds (19.5% and 34% respectively) than in freshly harvested lot (26% and 40% respectively). Oil content decreased under different RH and storage temperatures till the end of experimental period. Maximum loss in oil was noted in 90% RH at 30°C followed by storage temperatures of 20°C and 10°C. In 80% RH, it was comparatively very low at 10°C than those at 20°C and 30°C (Tables 1 and 2).

FAV

At harvest, FAV of both sesame and safflower oil was found to be within the range of values reported earlier (Joshi, 1961). It increased to a certain extent after 6 months in natural storage. Under different RHs and temperatures it increased gradually throughout the experimental period with maximum at 30°C and least at 10°C. In 80% RH, such increase was much less than in 90% RH at all tested temperatures.

DISCUSSION

Higher seed moisture accelerated fungal invasion subsequently resulting in loss of germinability and major food reserve. In the present study moisture in both seeds increased under different storage conditions, more so in safflower than in sesame seeds. This might partly be due to higher oil content and partly to hygroscopic properties of sesame seeds (Barton, 1961 ; Mondal *et al.* 1981). Seed moisture at given RH varied depending on the storage period and temperature and was always highest at 10°C (cf Barton, 1941). The increase in seed

Table 1. Effect of temperature, RH and storage period on seed health of safflower seed

Parameters	Initial		Storage period (days)	Fresh Seeds						6 Months Old seeds					
	Fresh 6 months seeds old seed			RH 80%		RH 90%		RH 80%		RH 90%					
	10°C	20°C		30°C	10°C	20°C	10°C	20°C	10°C	20°C	10°C	20°C	30°C		
Seed moisture (%)	9.4	13.0	30	9.8	9.7	9.4	14.0	12.2	11.2	13.2	13.0	12.9	16.1	15.0	14.5
			60	10.0	9.9	9.2	14.2	12.7	12.4	13.7	13.3	13.0	16.7	16.1	14.9
			90	10.4	10.5	9.5	16.7	14.8	12.7	14.2	13.8	13.0	18.2	16.8	14.7
Infection (%)	FF *	77.0	2.0	72.5	61.0	50.0	75.5	50.0	34.0	0.0	0.0	0.0	0.0	0.0	0.0
			60	70.0	35.5	28.5	54.0	30.1	17.5	0.0	0.0	0.0	0.0	0.0	0.0
			90	60.5	20.0	15.0	50.0	15.7	10.5	0.0	0.0	0.0	0.0	0.0	0.0
	SF *	5.0	60.0	30	10.5	14.0	20.0	12.0	38.5	26.5	64.5	77.0	70.0	70.1	100.0
			60	8.2	28.5	21.2	14.5	49.1	44.7	69.2	87.0	82.5	72.0	100.0	100.0
			90	11.1	28.0	27.2	14.0	56.0	52.5	69.0	94.5	90.0	74.0	100.0	100.0
Organic dry matter	100.0	96.9	30	100.0	99.4	98.0	98.0	98.0	96.8	96.9	96.7	96.0	95.6	93.8	93.3
			60	100.0	99.2	98.0	97.8	96.8	96.0	96.7	96.5	95.7	95.2	93.2	92.6
			90	100.0	98.3	97.2	97.7	95.9	95.5	96.6	95.4	95.1	95.5	93.0	92.0
Oil content	26.0	19.5	30	25.5	24.5	24.1	24.0	23.2	21.5	19.0	17.5	17.0	18.5	17.0	15.1
			60	25.2	23.5	23.0	23.7	21.6	20.7	19.2	17.3	16.8	18.2	16.0	13.3
			90	25.0	23.0	22.8	23.0	21.0	20.0	19.0	17.0	16.2	17.7	14.5	13.0
FAV	2.8	11.2	30	2.8	5.6	8.4	2.8	5.6	11.2	11.2	14.0	19.6	14.0	19.6	30.8
			60	2.8	5.6	11.2	5.6	11.2	14.0	11.2	16.8	22.4	14.0	28.0	33.6
			90	5.6	8.4	11.2	5.6	11.2	14.0	11.2	19.6	22.4	16.8	28.0	33.6

* SF = Storage Fungi. FF = Field Fungi.

Table 2. Effect of temperature, RH and storage period on seed health of sesame seed

Parameters	Initial		Storage period (days)	Fresh Seeds						6 Months old Seeds						
	1st lot	2nd lot		RH 80%			RH 90%			RH 80%			RH 90%			
				10°C 20°C 30°C			10°C 20°C 30°C			10°C 20°C 30°C			10°C 20°C 30°C			
				10°C	20°C	30°C	10°C	20°C	30°C	10°C	20°C	30°C	10°C	20°C	30°C	
Seed moisture (%)	4.1	7.0	30	5.1	4.5	4.0	7.2	6.4	5.9	7.9	7.2	7.0	10.5	10.0	8.1	
			60	5.7	4.8	3.8	7.8	7.2	6.1	8.2	7.4	7.2	11.1	10.5	8.7	
			90	6.8	5.7	4.0	8.4	7.9	6.3	8.7	8.4	7.3	11.3	10.8	8.5	
Infection (%)	FF *	5.0	0.0	30	4.0	4.0	2.5	4.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0	
				60	4.5	2.5	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				90	4.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Organic dry matter (%)	100.0	95.9	30	4.5	18.2	10.3	7.5	30.7	28.2	78.5	100.0	85.0	85.0	95.0	95.3	
			60	4.2	21.3	18.2	10.3	62.5	48.6	73.5	100.0	100.0	87.5	100.0	100.0	
			90	4.8	24.3	23.2	12.5	75.1	79.0	79.0	100.0	100.0	90.3	100.0	100.0	
Oil content (%)	40.0	34.0	30	100.0	99.0	99.0	97.9	96.8	95.0	95.8	94.7	94.2	94.5	93.1	91.4	
			60	100.0	99.0	98.9	97.5	96.1	94.9	95.8	94.4	94.0	94.0	92.5	91.8	
			90	99.7	98.5	98.1	97.2	94.3	93.2	95.6	94.0	93.5	93.8	91.0	90.2	
FAV	2.2	8.4	30	39.5	37.5	37.0	38.2	35.5	33.0	33.7	33.0	32.0	33.0	32.0	30.5	
			60	40.0	35.0	34.2	38.0	33.2	31.5	34.0	30.0	29.5	32.7	29.0	28.1	
			90	39.2	35.0	34.0	37.5	31.9	28.0	33.9	30.8	28.5	32.2	28.0	27.0	
Infection (%)	SF *	3.0	75.0	30	4.5	18.2	10.3	7.5	30.7	28.2	78.5	100.0	85.0	85.0	95.3	
				60	4.2	21.3	18.2	10.3	62.5	48.6	73.5	100.0	100.0	87.5	100.0	100.0
				90	4.8	24.3	23.2	12.5	75.1	79.0	79.0	100.0	100.0	90.3	100.0	100.0
Organic dry matter (%)	100.0	95.9	30	100.0	99.0	99.0	97.9	96.8	95.0	95.8	94.7	94.2	94.5	93.1	91.4	
			60	100.0	99.0	98.9	97.5	96.1	94.9	95.8	94.4	94.0	94.0	92.5	91.8	
			90	99.7	98.5	98.1	97.2	94.3	93.2	95.6	94.0	93.5	93.8	91.0	90.2	
Oil content (%)	40.0	34.0	30	39.5	37.5	37.0	38.2	35.5	33.0	33.7	33.0	32.0	33.0	32.0	30.5	
			60	40.0	35.0	34.2	38.0	33.2	31.5	34.0	30.0	29.5	32.7	29.0	28.1	
			90	39.2	35.0	34.0	37.5	31.9	28.0	33.9	30.8	28.5	32.2	28.0	27.0	
FAV	2.2	8.4	30	2.8	2.8	5.6	5.6	11.2	22.4	11.2	22.4	22.4	16.8	30.0	30.0	
			60	2.8	5.6	8.4	5.6	16.8	22.4	11.2	28.0	30.0	16.8	33.2	42.0	
			90	2.8	5.6	16.8	8.4	22.4	28.0	14.0	28.0	30.0	16.8	42.0	42.0	

moisture may partly be due to production of metabolic water by the fungi present (Dorworth and Christensen, 1968). Rate of increase in seed moisture was highest in the first 30 days but insignificant thereafter. It indicated that the seeds reached the equilibrium moisture at a particular temperature and RH and then further rise depended on seed respiration and metabolic water released from the fungal activity.

Germinability gradually decreased with longer storage under all tested conditions. It was more pronounced at higher RH and temperature. Quasem and Christensen (1960) reported that the major cause of germ damage in corn is the invasion of germs by storage fungi. In the present study, it is interesting to note that although fungal population was higher at 20°C than at 30°C germinability was totally lost at 30°C in both seeds at the end of experimental period. This finds support from Sauer and Christensen (1968) who reported that low germinability in corn was not consistently related to higher kernel infection by storage fungi. According to Bass *et al.* (1963) loss of viability of stored seeds was associated with the rate of respiration during storage. At higher temperature, the rate of respiration might presumably be increased thereby further increasing the temperature of seed. These physiological processes in co-ordination with accelerated fungal activity escalated the process of germ damage.

With the progress of storage the percentage of field fungi decreased gradually with the increase of storage fungi under all storage conditions. Extent of invasion by storage fungi depended on the moisture and temperature (Fields and King, 1962). At 10°C fungal invasion was lower even at the highest seed moisture. Sesame seeds were more readily invaded by storage fungi than safflower seeds reflecting thereby that the increase not only depended on the seed moisture but also on chemical composition of seeds as pointed out by Bass *et al.* (1963). Gradual elimination of field fungi might partly be due to absence of required level of seed moisture (Richardson, 1970) and partly due to their interaction with the storage fungi (Dorworth and Christensen, 1968).

Loss in organic dry matter was found to be related to high temperature, elevated seed moisture and high fungal activity there by consuming major food reserves of the seeds.

Oil content decreased gradually with longer storage (cf. Sharma, 1977; cf. Nagar and Chauhan, 1977). Breakdown of oil into fatty acids by lipases

of invading microflora or of the seed itself accounted for the loss in oil (Christensen, 1967). In the present study, decrease in oil content simultaneously with increase of FAV was higher at higher temperature. Dorworth and Christensen (1968) reported that whether FAV in stored grain would increase with increasing fungal invasion depended in part upon the moisture content of the seed. Thus, heavy invasion did not always result in higher FAV (Mc Gee and Christensen, 1970). It appeared that higher temperature activated lipases thus accelerating the breakdown of oil. Under identical condition, FAV of sesame seeds was higher than that of safflower though initially it was lower in the former. Some factors like thickness of seed coat, fatty acid composition or other inherent character in seed might partly be responsible.

It is evident that temperature and RH of storage atmosphere considerably influence biodeterioration of oil seeds. Deterioration is conspicuous within 6 months in unscientific natural storage. At high temperature and high RH (normally prevalent in India) there may be rapid loss of viability and sharp decrease in oil content and increase in FAV. Results obtained in seeds stored in 90% RH and 10°C show that the preservative effect of low temperature becomes considerably reduced when moisture is high (cf, Christensen, 1969). Storage at comparatively low temperature and RH and careful drying after harvest reduces the extent of deterioration.

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