"STUDIES ON THE INCORPORATION OF SAFFLOWER IL TO ENHANCE POLYUNSATURATED FATTY ACIDS IN BUTTER"

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BY

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This is to certify that the thesis entitled "STUDIES ON THE INCORPORATION OF SAFFLOWER OIL TO ENHANCE PUFA CONTENT IN BUTTER" submitted in partial fulfilment of the requirements for the degree of MASTER OF VETERINARY SCIENCE of the ANDHRA PRADESH AGRICULTURAL UNIVERSITY, HYDERABAD, is a record of the bonafide research work carried out by Sri K. VEERABHADRA REDDY under my guidance and supervision. The subject of the thesis has been approved by the Students' Advisory Committee.

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LIST OF ABBREVIATIONS

1. ANOVA: Analysis of variance
2. CHD: Chronic heart disease
3. FA: Fatty acid
4. FFA: Free Fatty Acids
5. GLC: Gas liquid chromatography
6. IV: Iodine value
7. meq/kg fat: milli equalents/kilogram
8. mg/g: milligrams/gram
9. PUFA: Poly unsaturated fatty acid
10. SFA: S turated fatty acid
11. SMP: Skim milk powder
12. USFA: Unsaturated fatty acid

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ABSTRACT

An investigation was carried out to study the feasibility of incorporation of safflower oil at 10%, 20% and 30% levels to enhance the levels of PUFA in butter and its effect on physico-chemical characteristics such as sensory evaluation, hardness, spreadability, I.V, Peroxide value, FFA content and Fatty acid profile of resultant butter blends. Butter manufactured in Chittoor MPF was used. Safflower oil sold in the brand name of 'SAFFOLA' was used in this study. The blends were stored at $0 \pm 1^{o}C$ for 40 days.

Butterblends with 10%, 20% and 30% safflower oil had same proximate composition of control butter. The Fatty acid profile of butter blends recognised an increase in PUFA content from 2.13±0.072 in control butter to 23.56± 0.926 in 30% level of safflower oil. Iodine value and spreadability significantly increased from control butter to 30% level of oil incorporation. Though a slight increase was noticed in both peroxide value and FFA content, they were found to be well within the acceptable level to impart any oxidative or lipolytic rancidity. Hardness has significantly decreased with an increase in oil incorporation, but it was observed that 30% oil level was maximum limit for obtaining optimum body and texture.

Sensory evaluation of the blends did not indicate any perceptible change in flavour, body and texture and also color and appearance. Increased level of oil incorporation imparted a lighter color to the product, but this was acceptable.

Storage studies at 10, 20, 30, 40 days intervals did not recognise any remarkable change in both the control butter and its blends.

Comparative economics of control butter and its blends (10%,20%,30%) on 100% fat basis worked out was Rs.58-00, 56-60 55-20,53-80 respectively. Further 30% level of oil incorporation had least cost of production.

CHAPTER I

1. INTRODUCTION

Dietary importance of fat has been well recognised by its virtue as a concentrated source of energy, essential fatty acids and also as a carrier of soluble vitamins. A balanced diet is therefore, often recommended to provide about 15% of the total calories in the form of fat.

Though the dietary fat is generally available from vegetable and animal sources, among sizeable segment of the world population, milk or its products are the major dietary items. Further, butter fat finds preference over vegetable fat due to the characteristic flavour, it contributes significantly towards this dietary constituent. Nutritionists and dietaticians alike, however, have serious apprehensions about this compositionally heterogenous constituent and it as one of the possible dietary risk factors associated with the incidence of coronary heart disease (CHD). The major link between the nutrition of the subject and the incidence of CHD has been identified to be blood plasma cholesterol level, which is greatly influenced by dietary factors.

In the light of this, dietary intake of animal fats, butter fat in particular, has been a matter of

much concern due to predominance of C_{12}: 0, C_{14} : 0, C_{16} : 0 fatty acids, which are potent in elevating plasma cholesterol level. Further more, low levels of PUFA together with high levels of saturated (S) one result in low PUFA: SFA ratio which with its excessive consumption is demonstrated to increase plasma cholesterol, triglycerides and phospholipid levels. The published reports from many parts of the world suggest an association between high intake of saturated fat and the prevalence of the coronary heart disease. It has also been observed that cholesterol level in the blood of heart victims is higher. Dairy products such as cream, butter and cheese are the main sources of increasing cholesterol in blood, a direct cause of heart attack or renal cardiac distribances. People have even gone to the extent of saying "somehow we have to get across the image that cow, so far depicted as a doe eyed gentle creature browsing in a pasture is a killer".

Inclusion of PUFA enriched animal fats were reported to lower plasma cholesterol levels. Thus increased uptake of essential fatty acids, decreases the risks of CHD. International dairy Federation-in the year 1974, strongly advocated the necessity to enhance in level of PUFA in milk fat either by manipulating the diet of milch animals or formulating a product in which milkfat is partially or totally replaced by appropriate amount of vegetable fats.

So an attempt has been made in the present investigation to incorporate safflower oil, which contains about 60-70% essential fatty acids (linoleic acid), in butter. The incorporation of oil in butter will not only increase PUFA, but also improve the spreadability of butter at low temperature coupled with lowering, the cost of production of butter, being cheaper than milk fat.

CHAPTER II

2. REVIEW OF LITERATURE

The present investigation aimed at development of a butter with enhanced PUFA by incorporating safflower oil. In the context of the scope of the present investigation, literature concerning composition of milk fats, importance of PUFA, composition of butter, safflower oil, methods of elevating the levels of PUFA in milk fat and butter and also the effect on blending of physico-ehemical characteristics of butter have been critically reviewed.

2.1 FATTY ACIDS COMPOSITION OF MILK FATS

The fatty acids composition of milk fat and their variation have been well established since a long time by Hilditch and co-workers who used classical methods in their analysis (Hildtich and Sleightholme, 1930, Hilditch and Thompson, 1936, Hilditch and Jasperson, 1943). However, very accurate fatty acid composition of milk fat including for the minor fatty acids as determined by GLC methods have been reported in recent literature (Smith, 1961, Gander _et al._, 1962, Jenson _et al._, 1962 a, de Man, 1964, 1965, Albonico _et al._, 1968 and Curcurachi and Lotito, 1968, Rama Murthy and Narayanan 1971) have studied the F.A. composition of

cow and buffalo milk fats collected in different seasons over a period of one year. The above authors definitely established that F.A. composition of buffalo milk fat distinctly differed from that of cow milk fat.

The typical fatty acid composition of cow and buffalo milk fats as determined by GLC analysis reported from different regions are shown in table-A.

Fatty acid composition (% W) of milk fats of cows and buffalo as reported by various workers.

Fatty acids	Cow milk fats						Buffalo milk fats	
	1	2	3	4	5	6	7	8
4.0	3.5	3.6	3.5	2.3	3.2	3.3	4.7	4.36
6.0	1.4	1.3	2.2	1.6	2.11	1.6	2.6	1.51
8.0	1.1	0.9	1.2	1.5	1.16	0.5	1.2	0.78
10.0	2.7	2.4	2.7	2.2	2.57	1.8	2.2	1.28
10.1	-	-	0.3	0.4	0.31	-	-	-
11.1	-	-	-	-	-	-	-	-
12.0	3.9	2.7	3.1	2.5	2.78	1.4	2.6	1.73
14.0	12.7	9.8	10.3	8.2	11.93	8.5	10.5	10.81
14.0	-	-	-	-	0.07	-	0.5	0.12
14.1 χ 15.0	-	-	2.1	2.6	2.12	1.5	1.2	1.27
15.0	1.0	1.1	1.0	-	1.23	1.2	1.6	1.29
16.0	--	-	-	-	0.30	-	0.3	0.18
16.1 χ 17.0	1.3	0.9	3.0	4.6	2.16	3.3	2.2	1.99
17.0	0.7	0.8	0.8	-	0.34	-	0.4	0.58
18.0	-	-	0.2	-	0.35	-	-	0.24
18.0	11.6	15.8	10.7	9.1	10.07	17.1	9.9	11.97
18.1	22.4	30.7	25.1	32.2	27.42	28.9	23.2	27.15
18.2	1.5	1.9	3.6	4.9	1.49	1.7	1.0	1.51
18.3	1.6	3.0	2.2	2.6	0.59	-	1.2	0.47

2.2 POLY UNSATURATED FATTY ACIDS

PUFA forms only a small proportion of total fatty acids of milk fat. The composition of PUFA in bovine milk fat was determined by many workers. Smith and Jack, 1954, Scott et al., 1959, Smith, 1961 and Boatman et al., 1965 by using alkali isomerisation method. Information on the PUFA composition of buffalo milk fat was, however limited. Tverdokhleb and Merzamatove (1965) compared PUFA content of buffalo milk fat with that of cow milk fat. Rama Murthy and Narayanan (1972) made a comparative study of the contents of PUFA in buffalo and cow milk fats and showed that buffalo milk fat contained higher levels of Tetraenoic and pentaenoic acids than cow milk fat.

2.2.1 Importance of saturated and Poly unsaturated fatty acids fats

The PUFA in milk fat gained increasing importance because of their role in auto-oxidation of fats and are dietary essential.

Beveridge et al. 1955 and Vergroesen, 1972 reported that low levels of PUFA(P) together with high levels of saturated one (S) resulted in low P:S ratio which with its excessive consumption was demonstrated to increase plasma cholesterol, triglyceride and Phospholipid levels

Vergroesen (1972) further reported the possible risk factors associated with the saturated fats to the incidence of coronary heart disease.

Renaud et al. 1979 noticed an increase in plasma cholesterol contents and the severity of atherosclerosis in rabbits fed on butter than those fed on Maize oil. Human studies involving groups of farmers living in VAR and MOSELLE Regions of France and KIRRIEMUIR, FRIAKHEIN and STRANRAER in Scotland, showed significant correlation between serum cholesterol and saturated fats.

NAKAI et al.(1986) observed the significant correlations between fasting plasma triglyceride and maximum plasma triglyceride after eating butter, margarine and cream. Maximum content of triglyceride, cholesterol, and Phospholipid in plasma were observed after eating cream than after eating butter or margarine. Differences between butter and margarine were not significant.

Keyes et al. (1957) reported that the safflower oil has kept down the serum cholesterol levels in patients suffering from hypercholesteraemia.

Niyogy (1966) reported the anti-cholesterol activity of safflower oil rich in PUFA.

Kinsell et al (1967) noticed the relationship of PUFA to lipid metabolism and atherogenesis.

Thompson (1969) described the salutory effect on cardiovascular disease by elevated levels of PUFA through enhanced synthesis of Prostaglandins which were potent inhibitors of Platelet aggregation.

Weiss (1971) observed the decreasing effect of Hypercholesteraemia when patients were administered diets rich in PUFA.

Fidenze (1972) reported that the restricted consumption of butter fat was shown to prevent the incidence of CHD.

Horustra et al (1973) reported the increasing Thrombiotic tendency of platelets in high PUFA levels which reduced the incidence of chronic heart disease.

However, Odendall et al (1980) suggested that there was no firm evidence to indicate that PUFA reduced the risk of ischaemic heart disease. In long-term trials with rats it has been found that incidence of heart disease and also of cancer was actually greater on diets of vegetable oils rich in Linoleic acid, than on diets of milk fats and other animal fats.

2.3 COMPOSITION OF BUTTER AND BLEND

According PFA rules (1976), Table butter should contain not less than 80% fat, less than 2.0% curd and 2.0% common salt.

Satish Kulkarni et al (1984), (1987), (1988) reported the composition of butter safflower oil blend. They further gave the composition as 80% fat, 16% moisture, 2% curd and 2% salt.

2.4 COMPOSITION OF SAFFLOWER OIL

Wilson et al (1971) noticed the saturated and unsaturated fatty acids contents of safflower oil.

Saturated	:	Palmitic	- 3.0%
		Stearic	- 4.0%
		Total	- 8.0%
Unsaturated F.A	:	Oleic	- 15.0%
		Linoleic	- 72.0%
		Total	- 87.0%

Swaminathan (1974) reported the relative amounts of USFA in safflower oil as

Linoleic acid - 78%

Linolenic acid - 0

Total USFA by Bio-assay - 78.8%

Daniel Swern (1982) reported that the safflower oil has highest linoleic acid content of any known oils and contained only about 5.7% saturated acids. Most safflower oils were essentially free of phosphatides, since they were removed during refining. High linoleic safflower oils contained about 33.0 mg/100 g total tocopherol. It contained about 1.5% total unsaponifiable matter.

Herb (1960) observed the safflower oil fatty acid composition by GLC and spectrophotometric analysis as

Safflower oil	Palmitale	Stearate	Total saturated	Palmito oleate	Oleate	Total mono enoate	Dino late	Lino lena-te
G 0.5 ul	7.5	2.8	10.3	-	13.6	16.6	76.1	-
L 1.0 ul	7.5	2.1	9.6	-	13.8	13.8	76.6	-
C 3.0 ul	7.1	2.5	9.6	-	12.2	12.2	78.3	-
U.V.	-	-	8.8	-	-	15.0	76.2	-

2.5 METHODS OF ELEVATING PUFA LEVELS IN BUTTER FAT

Several attempts have been made in recent years to augment the level of PUFA in milk fat either through intravenous infusion of PUFA or dietary administration of formaldehyde treated casein encapsulated vegetable oils to milch animals.

Tove and Mochrie (1963), Parry et al (1964), Hedrick T.I (1969), Storry et al (1969), Stewart and Irwine (1970), Scott et al (1970) and Steele et al (1971), Bitman et al (1975) reported an increase in PUFA (linoleic acid) content in milk fat through intravenous infusion of PUFA and also by biomanipulation of fatty acids composition of ruminant fats.

The observations that the unsaturated fat due to bio-hydrogenation was available only in saturated form to the ruminant body, coupled with the findings of Tove and Mochrie (1963), that the administration of polyunsaturated fats through duodenal or intravenous infusion brought about marked change in the fatty acid composition of milk had triggered research activities to develop ways and means to prevent biohydrogenation in rumen.

Scott et al (1970) putforth a brilliant idea to develop the protected fat Technology. The concept arose from two entirely unrelated developments. The use of formaldehyde treatment of oils to protect them from microbial degradation and technique for the manufacture of butter powder.

The dietary administration fof formaldehyde treated casein encapsulated vegetable oils have been attempted by several workers in recent years. Patel et al (1970), Scott et al (1971), Astrup et al (1972), Cook et al (1972), Pan et al (1972), Mattos and Palmquist (1974) reported an increase in linoleic acid content from 2-5% to 20-30% and they further stated the problems arising in the manufacturing of butter and the effects of high PUFA on Iodine value (an increase was noticed) ans softness (increased) of butter. This had triggered an era which has marked the manipulation of milk fat composition.

Pan et al (1972) marked that formaldehyde treatment of casein coated with the safflower oil not only eliminated the suppressing effect of safflower feeding on the milk fat, but it also resulted in an increase of fat percent. The increase was as high as 15 percent.

The fat that obtained was anslysed by Cook et al (1972). Their data revealed an increase in the proportion of C18:2 and C19:1 fatty acids and a corresponding decrease in that of C14 and C16 fatty acids content.

Plowman et al (1972) reported an increase in linoleic acid content from 3% to as high as 35% in milk fat of the animals fed with formaldehyde treated safflower oil.

Rindsig et al (1974) reported the incorporation of safflower oil in the diet of the animals and observed the effects on fatty acid composition of milk fats. They observed an increase in C18:1 and C19:2 fatty acids with a corresponding decrease in short chain (C4-C8) medium (C10-C14) and (C16-C18:0) some long chain fatty acids.

Wood et al (1975) reported that milk fat containing varied percents of Linoleic acid (from 1.8% to 28.0% of the fatty acids) could be produced by feeding cows, a protected lipid supplement and also by blending conventional and poly unsaturated milk fats.

Goering et al (1976) observed an increase in linoleic acid percent and also the effect on yield,

composition flavour and oxidative stability of milk by feeding protected safflower oil.

Timmen et al (1978) described the methods to modify the spreadability by changing the composition of butter fat by feeding encapsulated vegetable oils and addition of vegetable fats. That practice was most economical and technically practicable.

Hood et al (1981) reported the incidence of feeding cows with formaldehyde-treated PUFA seed supplement on fatty acid composition and distribution of particle size of milk fat globule. They further reported that the high linoleic acid has altered the processing procedure in the manufacture of butter and resulted in a decreased churning time.

Bath (1982) reported a change in the fatty acid composition of milk by protected fat feeding and butters made from such milks were found to have high linoleic acid content.

Cadden et al (1984a), (1984b) reported the preparation of butter from canola based protec fed animal milks and described the quality characteristics of such butters.

However the complexity of such techniques limited its operational utility.

In recent years several workers have attempted the addition of vegetable oils directly into the butters.

Bachanan and Rogeri (1973) described the manufacturing details and properties of butter prepared from milk fat rich in PUFA. This included direct blending of vegetable oil in the butter and noted the subsequent changes and problems encountered in the butter-vegetable oil blend.

Hehira et al (1976) described the development of a butter fat vegetable oil blend that would spread when taken straight from the refrigerator.

Forgerty et al (1980) announced the methodology for linoleic acid enriched milks, butters and cheese, which indicated that linoleic acid enriched milk, meat and dairy products were suitable for human consumption.

Dunkley (1982) noticed that the composition of fat in dairy products could be modified by fractionation, by blending with vegetable oils and by substituting vegetable oil for milk fat. This approach

which was used commertially in some countries, notably in Sweden, to produce "Dairy spreads".

He further observed an increased ratio of PUFA/ saturated fatty acids by blending. Bregott (A blend containing 80% milk fat and 20% soyabean oil) had been marketed in Sweden since 1969. In 1974 a related low fat product LATT, LAGOM was introduced, which contained 40% of a 60:40 mixture of milk fat and soyabean oil. Recently Australia has added regulatory standards for dairy blends for butter and margarine.

Fox (1982) prepared a blend from unhydrogenated soyabean oil and concentrated butter milk protein, which contained 48% moisture, 40% fat (60% butter oil and 40% soyabean oil), 7.5% protein, 1% CHO, 1.2% edible salts and various additives.

'DUKAT' a similar product was made in Czechoslovakia by using 40% fat cream which was emulsified with vegetable oil such as sunflower oil at a ratio of 27 to 73 parts and was enriched with vitamin A and E.

Two types of blends of butter were marketed in Australia one blend comprised of 80% fat which comprised of 83% milk fat, 14% corn oil and 3% sunflower oil.

Another type of blend contained 80-83% milk fat, 7-10% soya oil and 10.0% sunflower oil.

Moreau et al (1983) described a process for enriching milk and milk products with PUFA which involved the preparation of an oil-in-water emulsion (80:20) in a micronizer under a pressure of 3 bar, as observed in viggin sunflower oil with addition of Tocopherol at 90 mg/100 g, using sterile water as the aqueous phase. The emulsion was incorporated into skim milk to produce a product containing 33% as its lipid.

A typical process for production of butter spread by replacing 20% milk fat with soyabean oil to improve spreadability of butter was developed by Aage (1984).

Antenore et al (1984) developed a continuous churnless process for producing butter/vegetable fat spread. The method of manufacture include.

a) Concentration of 38-42% cream to a butter fat content of 80% of fat in a continuous separator.

b) The concentrated cream was homogenized at 1400-1500 Psi at 161-169°F to invert the oil in water emulsion to water in oil emulsion.

c) Then the inverted cream with hydrogenated vegetable oil was mixed in the ratio of 40:60.

Then cooled (the cream-oil mixture) at 44 to 56°F in a scrapped surface heat exchanger.

A method was standardized to prepare a low temp dairy spread by blending butter with safflower or sunflower oil at a minimum level of 30%.

Arsov (1984) described the preparation of a product from ripened-cream butter and sunflower oil in general terms.

Satish Kulkarni et al (1984), (1987), (1988) reported the incorporation of safflower oil in butter by direct blending in a mixer and further stated their rheological properties. They recommended that 30% oil incorporation was most economical, technically feasible and above all commercially viable in general terms.

Biernorth (1986) described the methodology for the manufacture of fat blends by direct blending of non-milk fat fraction containing specific glycerides.

Juttner et al (1986) described the process which involved production of (i) a fat phase and (ii) an

aqueous phase, mixing (1) and (ii) and churning. In examples, (i) comprising 40-50% of the spread and containing milk or vegetable fats and lecithin emulsifier (ii) comprised water and 10-30% of an ultrafiltrated of buttermilk, skim milk or whey. The reduced fat spreads contained 25-60% fat and flavourings.

Johansson et al (1988) noticed that butter like spreads spreadable at refrigeration temperature could be produced by emulsifying mixtures of vegetable oils, emulsifiers, and skim milk or butter milk and combining these at the same temp with the blends of milk fat and vegetable oil.

2.6 EFFECT OF BLENDING ON PHYSICO-CHEMICAL CHARACTERISTICS

2.6.1 Spreadability

The poor spreadability of refrigerated butter was largely due to the highly saturated nature of its component fatty acids and the spreadability of butter was closely correlated with Iodine value (Hill et al. 1938).

Tobias et al (1958) observed an increase in spreadability in butter blends to as high as 88% on bread.

Kapsalis et al (1963) observed the effect of additives on the spreadability of butters. The materials investigated included glycerides and vegetable oils etc. The results revealed that several vegetable oils were effective in improving the spreadability. When vegetable oils were added to the conventionally churned butter, the spreadability was improved by 10 to 44%. However, the additives did not appear to affect the keeping quality nor alter the chemical nature of the butter.

Dixon (1970) noticed an increase in spreadability of butters at low temperature (0-4°C) by modifying the constitution of butter fat.

Yoncoskie et al (1972) and Hehira et al (1976) reported an increased spreadability at refrigeration temperature with an increase in the PUFA content of butter fat.

Timmen (1978) reported an increase in spreadability of butter from PUFA enriched milks at room and refrigeration temperatures.

Aage (1984) presented a tabulated data on fatty acid composition which was used to show how the

replacement of about 20% of the milk fat with soybean oil improved the spreadability of dairy blends.

Satish Kulkarni and Rama Murthy (1985), (1987), (1988) reported an increase in the mean spreadability scores of butter with an increase in the level of vegetable oil (safflower oil) incorporation in butter.

Juttner et al (1986) noticed that milk fat-vegetable fat spreads which contained 25-60% fat and flavourings spread very well and could be stored for 6 weeks at 7°C without any change in the spreadability.

Gupta et al (1987) and Prajapathi et al (1987) observed an increase in the spreadability of butter rich in PUFA and indicated that this could be achieved by blending deodourized vegetable fat in butter.

Johansson et al (1988) observed an increase in spreadability of butter which contained 30-approximately 100% fat.

2.6.2 Hardness of butter

Kapsalis et al (1963) reported the effect of additives on the hardness of butter. They further reported a decrease from 3 to 21% in hardness of

butter with the addition of vegetable oils and glycerides etc. without altering the chemical nature of the butter.

Mickle et al (1963) noticed that the hardness of the butter was found to decrease with increased catalyst concentrations. A 50 ± 5% reduction in hardness was accomplished with vegetable oil concentration of 1-2%. This catalyst effect was related to the formation of diglycerides whose emulsifying properties partially explained the decreased butter hardness.

Bachanan and Rogeri (1973) reported that butter vegetable oil blend had a tendency to breakdown, oil off rapidly and had decreased hardness.

Scott et al (1978) reported that the softening poing of butter blends rich in PUFA was decreased by 30% reflecting the improved spreadability of polyunsaturated butter.

Bath (1982) reported that the butters made from milks rich in PUFA was soft when refrigerated and was more susceptible to oxidative rancidity due to higher unsaturation.

Mortensen et al (1982) observed a 35% decrease in firmness of butter incorporated with soybean oil measured at 7°C. He further noticed an interaction between hardness and Iodine value.

Satish Kulkarni and Rama Murthy (1985), (1987), (1988) observed a decrease in hardness of butter incorporated with safflower oil. They further noticed an increase in hardness with a decrease in temperature from 15°C to 0°C. The decrease in hardness was marked with an increase in the levels of addition of safflower oil in butter.

Patel et al (1989) presented the cone stress index of a protein enriched low fat spread to indicate hardness of product. They further observed that the hardness of butter spread had decreased with an increase in vegetable fat level in butter.

2.6.3 Iodine value

Kehar et al (1956) determined Iodine value of cows and buffalo fats which ranged from 27.4 to 40.5 (average 34.4). There were no significant variations in regard to Iodine value in cow and buffalo butter fat. Kankare (1974) determined Iodine value of milk fat and three of its solid fractions obtained at

24°, 18° and $12^{o}C$ as well as of the remaining liquid fat as 31.2, 24.9, 24.1, 28.7 and 40.5 respectively. Youseef et al (1977) reported that Iodine values of low melting fractions of milk fat were higher than of the high melting fractions. Similar observations have been made by Fjaervoll (1969) and Norries et al (1976) while studying the Iodine values of milk fat and its fractions.

Dixon (1964) reported an increase in Iodine value with a corresponding increase in the unsaturated fatty acids in butter fat.

Mortensen et al (1982) reported a decrease in Iodine value of butter samples from 35 to 32 results in an increase in butter firmness (of) by approximately 50%.

Satish Kulkarni and Rama Murthy (1987) reported an increase in Iodine value of butter from 29.8 - 34.3 (32.9) to 65.9 to 68.3 (67.2) in 30% safflower oil incorporated butter blend.

Johansson et al (1988) observed the Iodine value of a spread as 55-65 in butter which contained 30 - approximately 100% fat.

2.6.4 Peroxide value

Bachanan and Rogeri (1973) reported an increase in the peroxide value in butter/vegetable oil blend during the storage period for 6 weeks. He further indicated that peroxide value below 0.50 m.eq/kg fat was of acceptable quality regarding oxidation.

Cadden et al (1984a) (194b) reported no significant difference in butter blends with regards to peroxide value for one month. The initial peroxide value of the butter was 0.007 meg/kg fat and for the PUFA enriched butters it was found to be 0.051 meq/kg fat. They further stated that there was no change in storage stability of butter for one month.

2.6.5 FFA content

Sukumar De (1976) reported that the free fatty acid content of butter and butter oil was 0.2 to 0.5% oleic acid.

Cadden et al (1984a) (1984b) reported that the free fatty acids content of butter rich in PUFA was within the normal content of butter values of 0.2 to 0.5% oleic acid.

2.6.6 Sensory characteristics of butter and its blends

Miller (1968) reported similar butter flavours, color and appearance, and body and texture of butter vegetable oil blends. He further observed the long shelf-life of butter blends without spoilage or development of off-flavours under normal storage temperature of 24-38°C.

Edmondson *et al* (1972) reported that the flavour scores of milks evaluated one day after processing decreased with increasing amounts of Linoleic acid (C18:2) and decreased further on storage. Intensity of Oxidized flavour was marked after 24 hrs of storage.

Bachanan and Rogeri (1973) reported that butter rich in PUFA had a lighter color and further stated no serious flavour defects inspite of the rice in the peroxide value of butter blends.

Goering *et al* (1976) reported off-flavours predominantly of an oxidized nature, developed in milks containing high linoleic acid.

Hehira *et al* (1976) developed a butter fat/vegetable oil blend that was observed to have same flavour of butter. He further concluded that the flavour was

acceptable and recommended that 20% vegetable oil was suitable for commercial development. On storage at 5°C, the blend maintained an acceptable flavour for several months.

Fogerty et al (1980) reported that the linoleic acid enriched milks were suitable for human consumption.

Hood (1981) and Bath (1982) noticed that the high linoleic acid content in milk fat has increased susceptibility to lipid auto-oxidation and developed an oxidized flavours.

Arsov (1984) described a spread which has retained its initial organoleptic characteristics almost unchanged for 6 weeks at 6-8°C.

Cadden et al (1984a) (1984b) reported no significant difference in butter and butters rich in PUFA with regards to the flavour characteristics for one month.

Satish Kulkarni and Rama Murthy (1985), (1987), (1988) reported non-significant changes in flavour, color and appearance of the butter-safflower oil blend to control butter. They further observed an improvement in color and appearance by whipping and recommended completely deodourised safflower oil to avoid flavour defects.

Biernorth et al (1986) developed a spread, which was reported to have same sensory and textural properties as that of control butter.

CHAPTER III

3. MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Butter

Sweet cream (unripened) butter was prepared using cream with the usual and standard procedure adopted in the milk products factory, Chittoor (Appendix I).

3.1.2 Vegetable oil

Refined and deodourised safflower oil sold in the brand name of SAFFOLA manufactured by M/S Hindustan Levers Ltd., Bombay was used for blending purposes.

3.1.3 Skim milk powder

Skim milk powder spray dried, sold in the brand name of SAGAR manufactured by Mehsana District Co-op Milk Producer's Union Limited, Mehsana-1S: 1165.

3.1.4 Salt

Sodium chloride extrapure M/S Sarabhai M Chemicals Limited was used in butter at 2% level. Salt has been added to the butter while the butter was at working stage. Salt was added by sprinkling the salt on butter and worked to ensure uniform distribution.

3.2 CHEMICALS

Iodine Monochloride (Icl) - Merck India Limited, Bombay.

Glacial acetic acid - Merck India Limited, Bombay.

Sodium Thiosulphate - Merck India Limited, Bombay.

Starch Extrapure - Reidel (India) Chemicals.

Carbon Tetrachloride - Reidel (India) Chemicals.

Pot Iodide - BDH lab chemicals.

Chloroform - Reidel (India) chemicals.

Calcium carbonate - Sarabhai M chemicals.

Sodium Hydroxide - Merck India Limited.

Neutralized Alcohol - Merck India Limited.

Sodium Metal - Reidel (India) Chemicals.

Methanol - Sarabhai (M) Chemicals.

Ammonia - BDH Lab Chemicals.

Petroleum and diethyl ether - Reidel (India) Chemicals.

3.3 METHODS OF TESTING

3.3.1 Butter

Butter was analysed on the day of preparation for fat, moisture, curd and salt.

3.3.2 Fat

Butter fat was estimated by Mojonnier Method as per the procedure described in Instructions Manual for setting up and operating the Mojonnier Milk tester. Bulletin

3.3.3 Moisture

Moisture content of butter was estimated as per the procedure described in ISI Hand Book of Food analysis part XI. SP 18 (part XI) - 1981, 64.2.2.

3.3.4 Curd

Curd content of butter was estimated as per the procedure described in ISI, Hand Book of Food analysis part XI. SP 18 (part XI) - 1981, 65.3.

3.3.5 Salt

Salt content of butter was estimated as per the procedure described in ISI, Hand Book of Food analysis part XI. SP 18-1981.

3.4 CONTROL BUTTER

The composition of butter was kept to the described standards of Table butter. Control butter was prepared according to the usual procedures.

3.4.1 Butter - Vegetable oil (safflower oil) blend

Control butter was tempered by keeping in an incubator at 20°C for 3-4 hrs. So as to obtain a consistency suitable for blending purpose. The blending of vegetable oil was done in Sumeet Mixer as follows.

Calculated amounts of butter and vegetable oil were transferred to the bowl of the mixer along with moisture, skimmed milk powder (SMP) and salt to obtain 16% moisture 2% curd, 2% salt in the final blend. The mixture was blended thoroughly in the mixer for at least 40 minutes to obtain a uniform consistency in the final product. The product was transferred to wooden moulds and it was kept at $0^{o}C$ for hardening. Saffola has been incorporated in the control butter at 10, 20 and 30% levels.

3.4.2 Composition of blend

The final composition of control butter and experimental butter is given in Chapter IV. This has been arrived at after considering various combinations and stability factors of oil incorporation into butter.

3.5 PHYSICAL TESTS

3.5.1 Sensory evaluation

The sensory quality of butter was assessed by a panel of 5 judges from Department of Dairy Technology, College of Veterinary Science, Tirupati.. At different intervals of periods, members were asked to determine the sensory characteristics of butter. Each panel member did this by spreading a part of butter on bread

with a table knife at uniform temperature of 5 ± 1°C. The panelists were instructed to rate each sample on 9 point Hedonic Scale.

HEDONIC SCALE

SENSORY SCORE CARD (A 9 POINT HEDONIC SCALE)

Liked Extremely	-	9
Liked very much	-	6
Liked moderately	-	7
Liked slightly	-	6
Neither liked nor disliked	-	5
Disliked slightly	-	4
Disliked moderately	-	3
Disliked very much	-	2
Disliked extremely	-	1

Characteristics	Sample No.			
	1.	2.	3.	4.
Flavour				
Body and Texture				
Colour and appearance				

3.5.2 Hardening

The hardness of butter and its blends was measured in terms of penetration value with the help of penetrometer

at $15^{o} \pm 1^{o}C$. The butter mould was placed on the platform provided in the penetrometer. The cone of penetrometer was just adjusted to touch the surface of the butter. The cone was then released to penetrate the block for exactly 10 sec. The distance through which the cone penetrated into the butter was reflected on the dial of the penetrometer. At least 5 observations were taken for each mould at different points leaving at least one inch between two points. The average of the 5 observations was taken as the penetrometer reading (Dixon and Parekh 1979).

3.5.3 Spreadability

Spreadability of butter was taken at $5 \pm 1^{o}C$. Judges were asked to observe the spreadability. Each panel member did this by spreading a part of butter on bread with a table knife at uniform temperature. The panelists were instructed to rate each sample on objective evaluation.

3.6 CHEMICAL TEST:- The butter fat has been extracted by Mojonnier Method.

Mojonnier Method of Butter fat extraction

For first extraction, 1.0 gm of sample was taken into the extraction flask. To this 8 ml of water, 1.5 c.c. of ammonia was added. 10 c.c. of alcohol, and 25 c.c. of

each ethyl and petroleum ethers were added. Shaked thoroughly after the addition of the alcohol, and 20 seconds after the addition of each of the two ethers. Centrifuged it for one-half minute.

For the second extraction, neither water nor ammonia was added. 5 c.c. of alcohol 25 c.c each of ethyl and petroleum ether was added and shaken for 20 seconds after the addition of each reagent. Contrifuged for one-half minute. The contents were changed to a dish which was to be kept at 135°C for five minutes. After the evaporation of the ether, the dish was kept in the cooling desiccator for seven minutes. Then the butter fat was ready for further analysis. This fat was used for estimating Iodine value, peroxide value. Free fatty acids content and also for GLC analysis.

3.6.1 Iodine value

Iodine value of butter samples were estimated as per the procedure described in ISI Hand Book of Food analysis part XI. SP 18 (part XI) 1981.

Wijs' Method

Clear fat of 0.40 to 0.45 g weight was taken into a clean clarified conical flask. The fat was dissolved

in 15 ml of carbon tetrachloride and 25 ml of Wijs' reagent (Iodine Monochloride glacial acetic acid) was added to the dissolved fat by means of a burette. The flask was closed with a stopper. The contents were mixed carefully and allowed to stand for 1 hr in the dark. 20 ml of potassium Iodine solution and approximately 150 ml of distilled water were added and mixed. The contents were then titrated with 0.1 N Sodium thiosulphate solution (using 2 ml of starch as an indicator) swirling the liquid constantly. The starch solution was added shortly before the end of the titration and the contents were shaken vigorously. A blank test was carried out subsequently using the same quantities of the reagents.

$$I.V = \frac{12.69\ (B-S)\ N}{W}$$

B = volume in ml of standard sodium thiosulphate solution for the blank.

S = volume in ml. of standard sodium thiosulphate solution required for the sample.

N = Normality of standard $Na_2S_2O_3$ solution and

W = weight in g of the material taken for the test.

3.6.2 Peroxide value

Peroxide value (expressed as milli equivalents of of peroxides per kg of fat) was determined as per official methods of analysis of A.O.A.C.(1980).

3.6.3 Free fatty acids

FFA value of butter samples (expressed as percent oleic acid) were estimated as per the procedure described in ISI Hand Book of food analysis part XI SP 18 (part XI) 1981, 84.5, 94.

3.6.4 Fatty acid profile

Fatty acid profile was determined by gas liquid chromatography (GLC)

Procedure for GLC

3.6.4.1 Gas-liquid ehcomatography of fatty acids

The fatty acid profile of the butter samples were determined by gas liquid chromatographic (GLC) technique after converting the samples in their methyl esters.

3.6.4.2 Extraction of fat

Fat was extracted from the butter sample by Mojoinnier method.

3.6.4.3 Preparation of fatty acid methyl esters

Fatty acid methyl esters of butter fat were prepared by the sealed tube method of De Man (1964). The sample of fat was weighed (40-50 mg) in glass ampoule

to which double volume of 0.2 N sodium nethoxide was added. The ampoule was heat sealed and kept in an oven at 80°C for esterification of fatty acids until a uniform layer was formed. At the time of analysis ampoules were broken and sample was injected without further treatment.

3.6.4.4 Operating parameters for GLC analysis

GLC analysis was carried out in a double column gas chromatograph (Aimil - NocoN 5700; Japan) fitted with FID, temperature control modules, and single pen recorder Amniscribe. A 6 ft x 1/4 inch glass column was packed with DMCS-80-100 (support), DEGS-15% (liquid phase). The sample was injected at an initial temperature of 70°C and the temperature was programmed to rise at the rate of 4°C/min to final temperature of 200°C. The temperature of injection port and detector was 220°C. Nitrogen was used as carrier gas.

FID module control: Atinuation : 8, Sensitivity: x100

Temperature control module: Injection temperature: 220°C; Detector Temperature 220°C; Oven temperature:70-200° programme 4°C/min.

Carrier Gas : N_2 30 ml/min.

Fuel: H_2: 35 ml/min and O_2: 300 ml/min.

Recorder: volt: 0.01 and chart speed: 1 cm/min.

Sample size: 0.15 u litre.

3.6.4.5 Identification of fatty acid peaks and calculation of peak areas

Areas under each peak was obtained by multiplying peak height by peak width at half height. (KEULEMANS A.I.M. GAS CHROMATOGRAPHY. 2nd ed. REINHOLD PUBL CORP, NEW YORK. 1959).

3.6.5 Storage studies

A 40 days storage studies were conducted. The butter-blend samples were analysed at the regular intervals of 0, 10, 20, 30 and 40 days for physical and chemical parameters.

3.6.6 Comparative cost studies

Production cost of above kind of butter blends was calculated as per the lastest rates.

3.6.7 Statistical analysis

Statistical analysis of the data was carried out as per the procedure laid down in Snedecor and Cochran (1967).

CHAPTER IV

4. RESULTS

This section deals with the observations obtained on various aspects viz., composition of butter, composition of blends fatty acid profile of control butter, it's blends and effect of blending safflower oil at 10%, 20% and 30% levels on Iodine value, peroxide, free fatty acids contents, sensory evaluation, hardness and spreadability of the butter during the present investigation.

4.1 COMPOSITION OF BUTTER AND ITS BLENDS

4.1.1 Fat

The results pertaining to the fat content in control butter and it's blends with 10%, 20% and 30% safflower oil and changes in fat content during subsequent storage for 40 days are presented in table.1.

It may be seen from the table that the average fat content of control butter and it's blends with 10%, 20% and 30% safflower oil was found to be 80.05, 80.03, 80.03, 80.05 percent respectively. It may be further seen that the fat content remained fairly constant during storage period of 40 days both in control and it's blends.

Table 1: Fat content(%) of control butter and butter-safflower oil (10%, 20% and 30%) blends.

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	80.05	79.95	80.13	80.00	79.98
10%	80.03	80.03	80.18	80.10	80.08
20%	80.03	80.08	79.95	80.00	80.05
30%	80.05	80.05	80.03	80.03	79.98

Statistical analysis of the data (Table 2) did not indicate any significant difference in the levels of fat content observed either in control butter or it's blends. Further it did not recognize any variation in the levels of fat during storage period.

4.1.2 Moisture

The results in Table 3 represents the moisture content in control butter and it's blends with 10%, 20% and 30% safflower oil and changes in moisture content during subsequent storage for 40 days.

It may be seen from the table that the average moisture content of control butter and it's blends with 10%, 20% and 30% safflower oil was found to be 16.0, 15.98, 15.95, 15.95 percent respectively. It may be further noticed that the moisture content remained fairly constant during storage period of 40 days in control butter and it's blends.

Statistical analysis of the data (Table 4) did not indicate any significant difference in the levels of moisture content observed in either control butter or it's blends. Further it did not indicate any significant variation in the levels of moisture during storage period.

Table 2: Anova table for fat content in control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean squares	F Ratio
Between trials	3	0.0488	2.3647
Between treatments (F_1)	3	0.0138	0.6684
Treatments	19	0.0085	0.4142
Between storage periods (F_2)	4	0.0142	0.6876
Interaction ($F_1 \times F_2$)	12	0.0054	0.2595
Error	57	0.0206	
Total	79		

Table 3: Moisture content (%) of control butter and butter-safflower oil (10%, 20% and 30%) blends.

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	16.0	16.0	15.95	15.97	16.0
10%	15.97	15.97	16.00	15.95	15.80
20%	15.95	15.97	16.10	16.10	15.97
30%	15.95	15.92	15.95	16.00	16.05

Table 4: Anova table for moisture content in control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean squares	F Ratio
Between trials	3	0.0108	0.7885
Between treatments (F_1)	3	0.0141	1.0320
Treatments	19	0.0117	0.8552
Between storage periods (F_2)	4	0.0301	2.2011
Interaction ($F_1 \times F_2$)	12	0.0050	0.3623
Error	57	0.0237	
Total	79		

4.1.3 Curd

The results pertaining to the content of curd in control butter and its blends with 10%, 20% and 30% safflower oil and changes in curd content during subsequent storage for 40 days are presented in Table 5.

It may be noticed from the table that the average curd content of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 2.05, 2.00, 2.03, 1.95 percent respectively. It may be further noticed that the curd content remained fairly constant during the 40 days storage period both in the control butter and its blends.

Statistical analysis of the data (Table 6) did not indicate any significant difference in the levels of curd content, observed in control butter or its blends. Further it did not recognize any significant variation in the levels of fat during storage period.

4.1.4 Salt

The results given in the Table 7 represents the salt content in control butter and its blends with 10%, 20% and 30% safflower oil and changes in salt content during subsequent storage for 40 days.

Table 5: Curd content (%) in control butter and butter-safflower oil (10%, 20% and 30%) blends.

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	2.05	2.02	1.92	2.02	1.95
10%	2.00	2.02	1.92	2.00	2.00
20%	2.02	2.05	1.95	1.97	2.00
30%	1.95	1.97	2.05	2.00	1.92

Table 6: Anova table for curd content in control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean squares	F Ratio
Between trials	3	0.0108	0.8978
Between treatments (F_1)	3	0.0021	0.1768
Treatments	19	0.0069	0.5753
Between storage periods (F_2)	4	0.0064	0.5356
Interaction ($F_1 \times F_2$)	12	0.0083	0.6881
Error	57	0.0120	
Total	79		

Table 7: Salt content (%) in control butter and butter-safflower oil (10%, 20% and 30%) blends.

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	1.95	2.02	2.0	2.0	2.07
10%	2.0	1.97	1.90	1.95	1.97
20%	2.05	1.90	1.97	1.92	1.97
30%	2.05	1.97	2.10	2.00	1.92

It may be observed from the table that the average salt content of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 1.95, 2.0, 2.05, 2.05 percent respectively.

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It may be further added that the salt content remained fairly constant during the storage period of 40 days in both control butter and its blends.

Statistical analysis of the data (Table 8) did not show any significant difference in the levels of salt content observed in either control butter or its blends. Further it did not indicate any significant variation in the levels of salt during storage period.

4.2 FATTY ACID PROFILE OF CONTROL BUTTER AND ITS BLENDS WITH 10%, 20% AND 30% SAFFLOWER OIL

The chromatograms of fatty acid profile of control butter and its blends with 10%, 20% and 30% safflower oil obtained by GLC were displayed in Figs 1, 2, 3 and 4. The identity and relative proportions of various fatty acids under each peak are given in Table 9.

It may be inferred from the data presented that the proportion of saturated fatty acids and unsaturated fatty acids in control butter was found to be

Table 8: Anova table for salt content in control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean squares	F Ratio
Between trials	3	0.0101	0.1609
Between treatments (F_1)	3	0.0145	0.6578
Treatments	19	0.0120	1.3721
Between storage periods (F_2)	4	0.0129	1.4834
Interaction (F_1 x F_2)	12	0.0110	1.2636
Error	57	0.0087	
Total	79		

Table 9: Fatty acids distribution of control butter and its blends with 10%, 20% and 30% safflower oil obtained by GLC Technique

Fatty acids	Control	10%	20%	30%
C4	3.906±0.0102	3.610±0.0912	3.376±0.1136	3.255±0.0813
C6	2.084±0.931	1.510±0.7681	1.126±0.3251	1.124±0.5365
C8	2.208±0.321	1.135±0.4913	1.017±0.2191	0.98±0.0916
C10	2.035±0.0808	1.83±0.1081	0.769±0.3123	0.584±0.05223
C12	1.8741±0.0321	1.58±0.0421	1.347±0.0813	1.17±0.1126
C14	11.880±0.8121	11.13±0.9286	11.355±0.8182	9.39±0.9321
C16	34.672±1.0801	32.27±0.0129	29.87±1.1391	26.70±0.9622
C18:0	12.617±0.412	11.03±0.6123	10.307±0.823	10.01±0.8667
C18:1	27.50±1.012	26.10±0.9871	24.10±0.6282	23.539±0.821
C18:2	2.13±0.072	9.52±0.8113	16.756±0.7391	23.56±0.9291
USFA	29.63	35.62	40.86	47.10
SFA	70.37	64.38	59.16	52.90

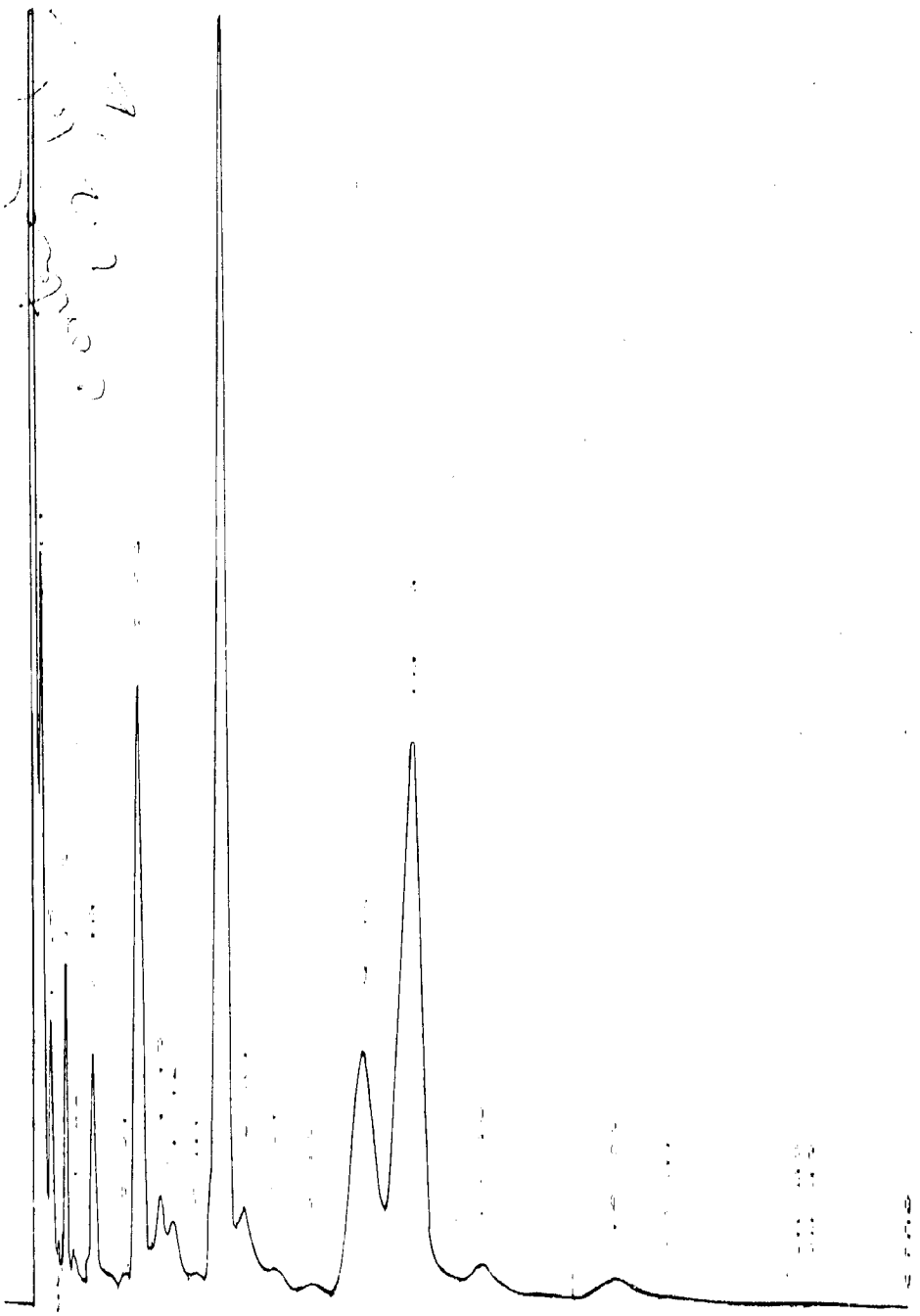

Fig 1: FATTY ACID PROFILE - BUTTER (CONTROL)

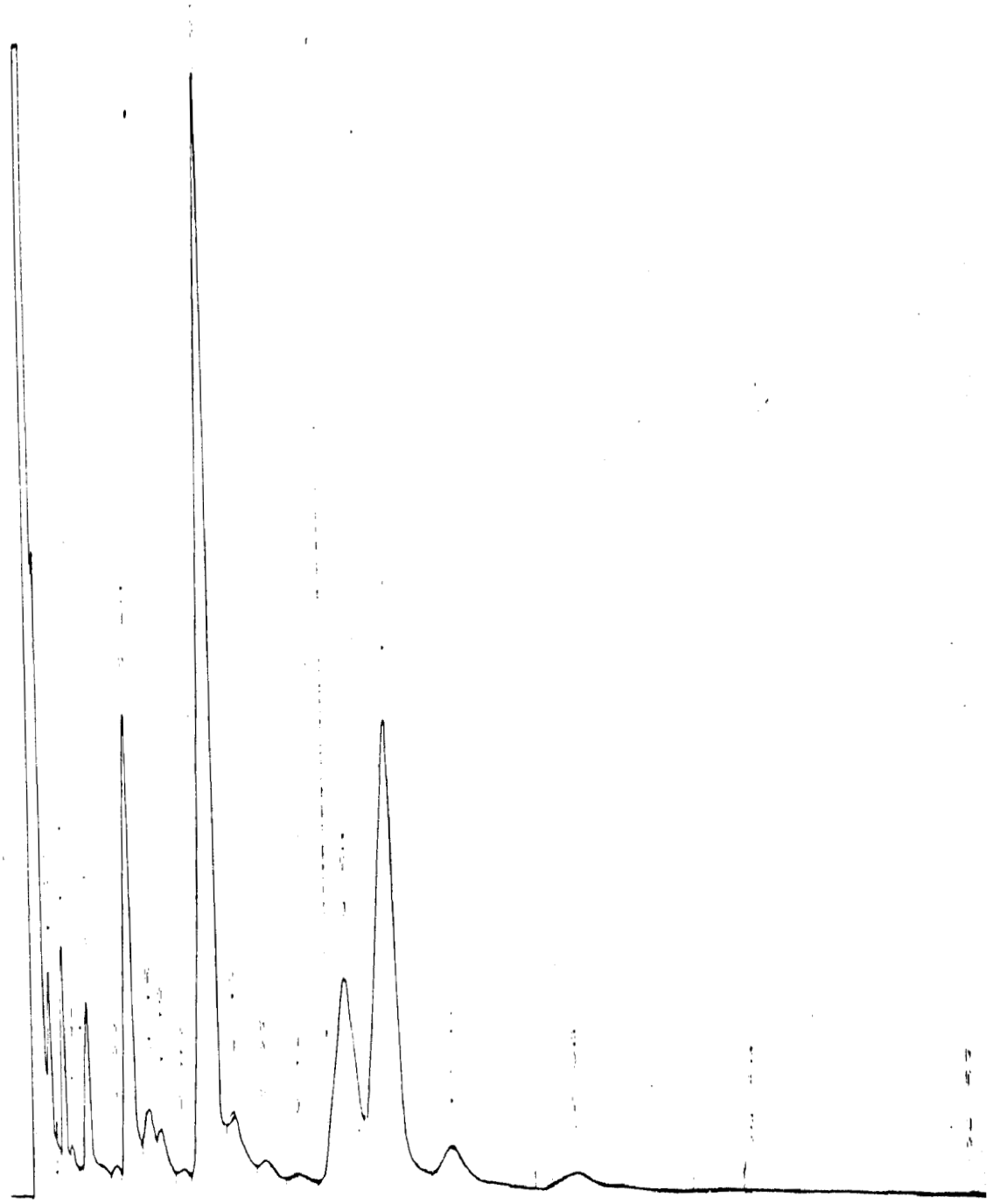

Fig 2: FATTY ACID PROFILE - BUTTER BLEND (10% SAFFLOWER OIL)

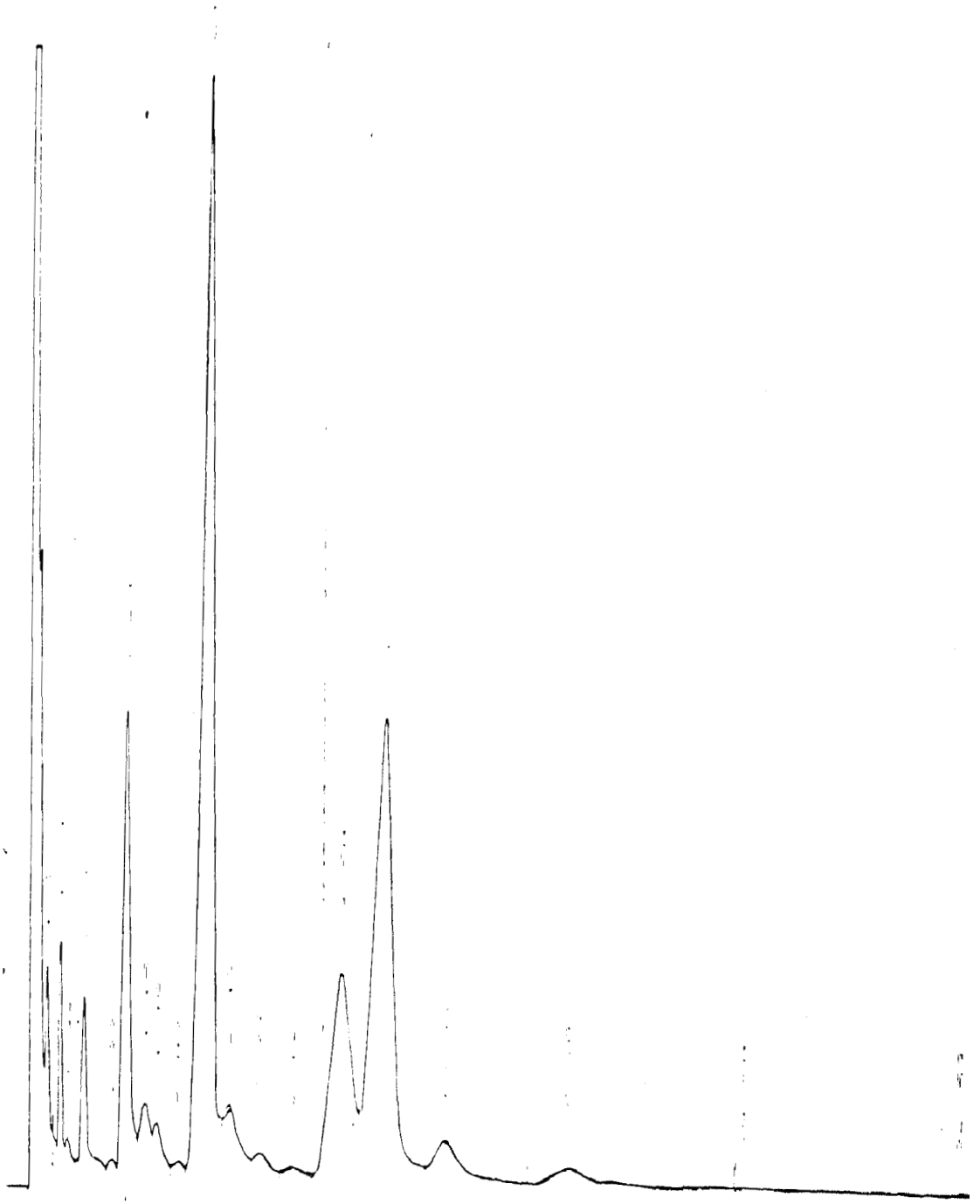

Fig 2: FATTY ACID PROFILE - BUTTER BLEND (10% SAFFLOWER OIL)

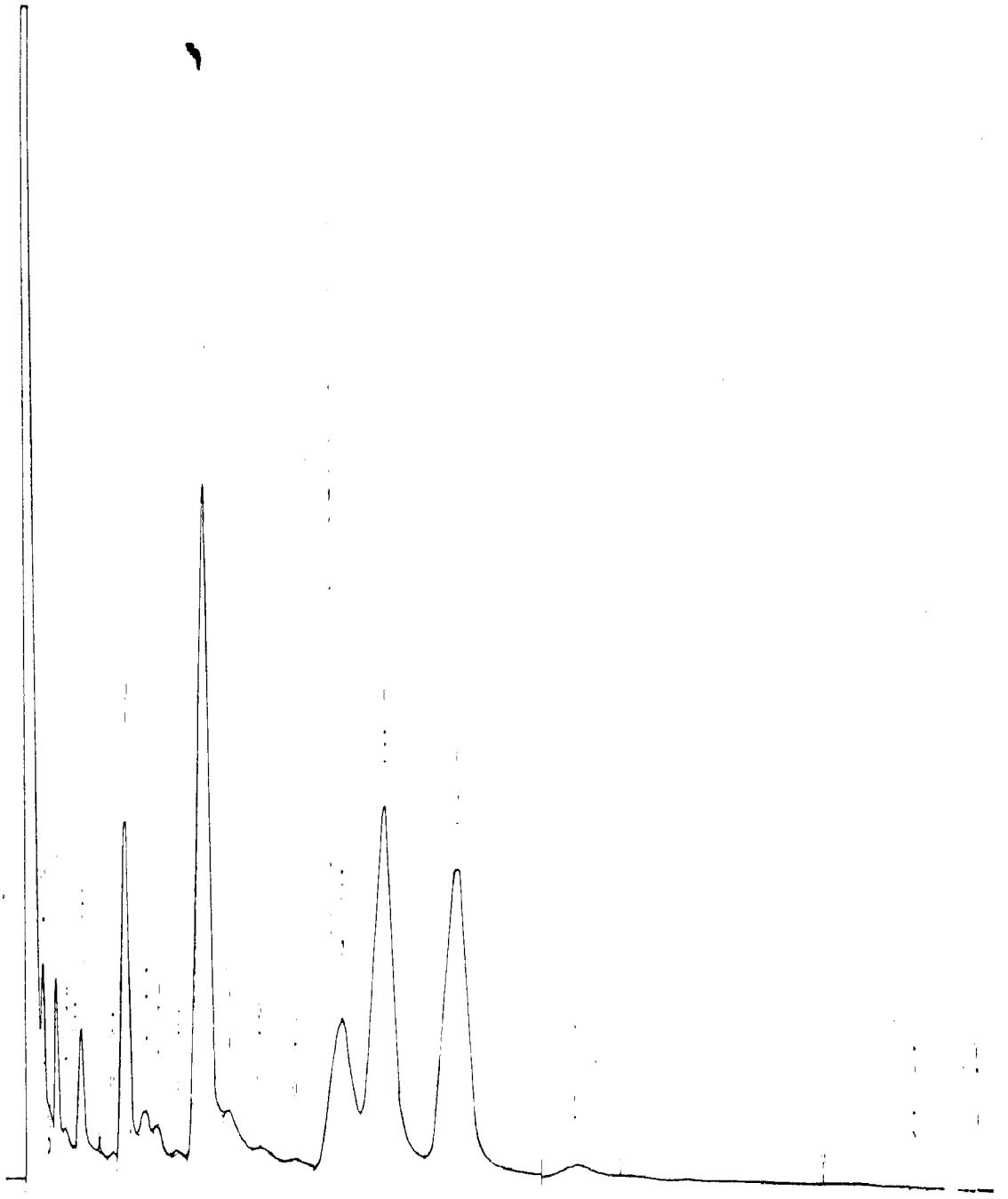

Fig. 2. FATTY ACID PROFILE - PUMPED BLEND (80% [illegible]

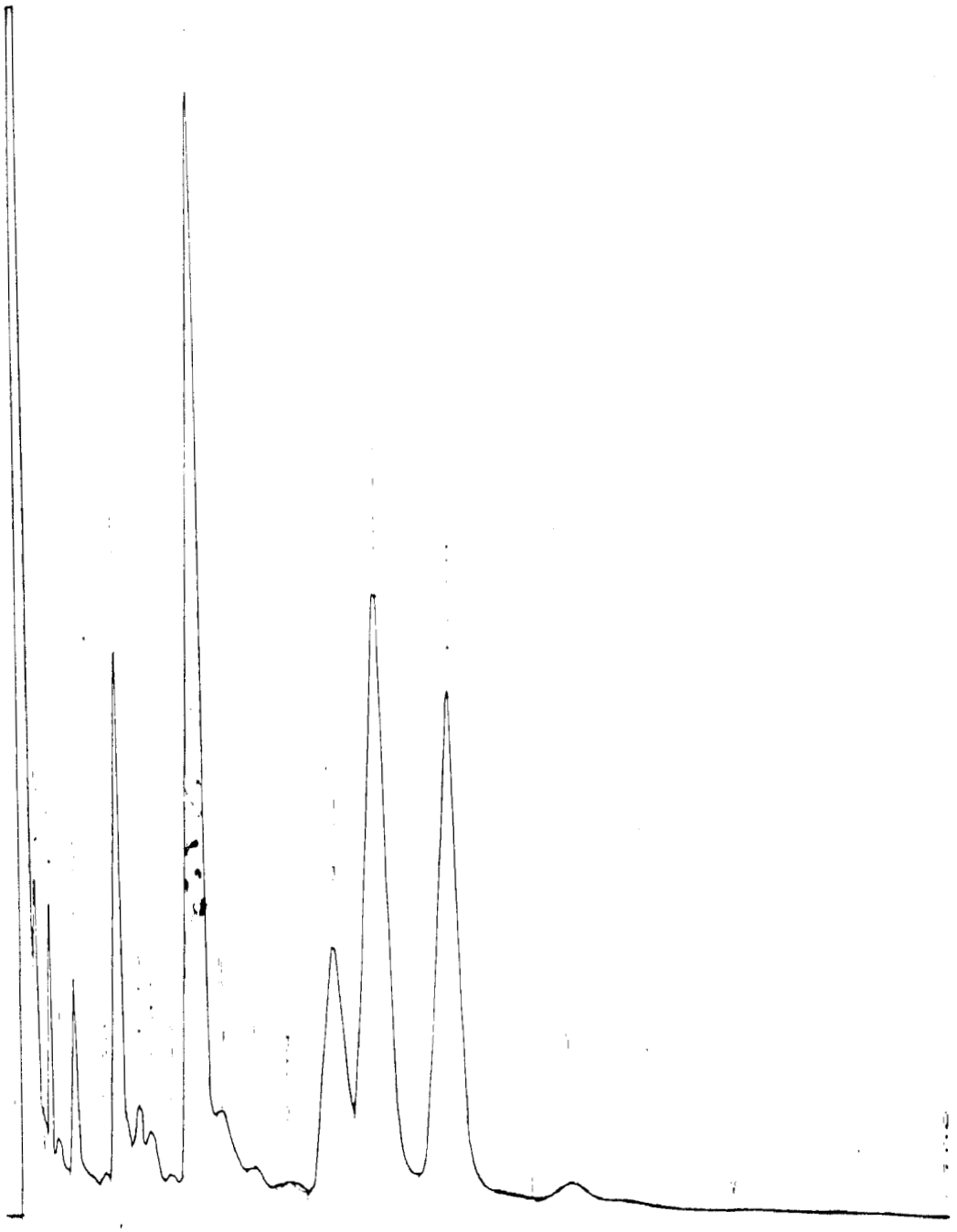

Fig 4: FATTY ACID PROFILE - BUTTER BLEND (30% SAFFLOWER OIL)

71.27% and 29.63% respectively. It may be further seen that the proportion of SFA/USFA in the blends with 10%, 20% and 30% safflower oil were found to be 61.10: 35.62, 59.55:40.85, 53.21:47.10 percentages respectively.

Compared to control butter, there was significant change in the proportion of polyunsaturated fatty acid content (Linoleic acid) in the blends with 10%, 20% and 30% safflower oil blends. Further it may be observed from the figures that the fatty acids from control butter and its blends with 10%, 20% and 30% safflower oil displayed similar elution pattern. The proportions of unsaturated fatty acids viz., C18:1, C18:2 in control butter and its blends were found to be 29.63, 35.62, 40.86, 47.10 percent respectively, compared to the control butter, significant changes could be observed in the proportions of unsaturated fatty acids in butter blends with 10%, 20% and 30% safflower oil.

4.3 EFFECT OF BLENDING SAFFLOWER OIL AT 10%, 20% AND 30% LEVELS IN BUTTER

4.3.1 Iodine value

The results of Iodine value of control butter and its blends with 10%, 20% and 30% safflower oil and changes in Iodine value during subsequent storage for 40 days are displayed in Table 10.

Table 10: Iodine value of control butter and its blends with 10%, 20% and 30% safflower oil

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	30.35	30.65	30.10	30.29	31.33
10%	41.26	41.39	41.01	41.02	41.56
20%	53.17	53.93	53.73	53.72	54.54
30%	70.45	70.66	70.71	70.69	60.59

It was observed from the table that the average Iodine value of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 30.35, 41.55, 53.165, 70.45 units respectively. It was further noticed that the Iodine value remained fairly constant during storage period of 40 days both in control and its blends.

Statistical analysis of the data (Table 11) showed highly significant difference (P 0.01) in the levels of Iodine value between control butter and its blends with 10%, 20% and 30% safflower oil. Further, it did not reveal any variation in the levels of Iodine value during storage period.

4.3.2 Peroxide value

The results pertaining to peroxide value of control butter and its blends with 10%, 20% and 30% safflower oil and changes in peroxide value during subsequent storage for 40 days are documented in Table 12.

It may be noticed from the table that the average peroxide value of control butter and its blends with safflower oil was foun to be 0.008, 0.011, 0.017, 0.018 meq/kg fat. Further it may be noticed, that the peroxide value remained fairly constant during subsequent storage for 40 days in both control butter and its blends.

Table 11: Anova table for Iodine value of control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean Squares	F Ratio
Between trials	3	5.4661	2.7943
Between treatments (F_1)	3	269.9385	137.9923**
Treatments	19	943.7983	482.4688
Between storage periods (F_2)	4	0.0544	0.0278
Interaction ($F_1 \times F_2$)	12	1426.8445	729.4016
Error	57	1.9562	
Total	79		

** Significant at 1%

Table 12: Peroxide value (meq/kg/fat) of control butter and its blends with 10%, 20% and 30% safflower oil

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	0.008	0.011	0.012	0.011	0.013
10%	0.011	0.015	0.016	0.015	0.019
20%	0.017	0.019	0.019	0.019	0.019
30%	0.019	0.019	0.020	0.020	0.022

Statistical analysis of data (Table 13) did not reveal any significant difference in the peroxide value of control butter and its blends. Further, the variation in peroxide value in both control butter and its blend was insignificant.

4.3.3 FFA content

The results pertaining to FFA content of control butter and its blends with 10%, 20% and 30% safflower oil and subsequent changes during storage period for 40 days are presented in Table 14.

It may be noticed from the table that the average FFA content of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 0.214, 0.316, 0.384, 0.407 respectively. It may be further observed that the FFA content remained fairly constant during storage period of 40 days both in control butter and its blends.

Statistical analysis of the data (Table 15) indicated ($P < 0.01$) significant difference in FFA content of control butter and its blends. Further it did not show any variation in the levels of FFA during storage period.

Table 13: Anova table for peroxide value of control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean squares	F Ratio
Between trials	3	0.0016	2.2658
Between treatments (F_1)	3	0.0009	1.3246
Treatments	19	0.0009	1.2434
Between storage periods (F_2)	4	0.0015	2.1774
Interaction ($F_1 \times F_2$)	12	0.0006	0.9118
Error	57	0.0007	
Total	79		

Table 14: Free fatty acid content of control butter and its blends with 10%, 20% and 30% safflower oil

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	0.214	0.216	0.245	0.255	0.281
10%	0.316	0.318	0.336	0.340	0.362
20%	0.384	0.388	0.394	0.402	0.406
30%	0.407	0.409	0.417	0.422	0.424

Table 15: Anova table for FFA value of control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean squares	F Ratio
Between trials	3	0.0001	2.0853
Between treatments (F_1)	3	0.0354	1309.3137
Treatments	19	0.0420	1555.8581
Between storage periods (F_2)	4	0.0008	3.0870
Interaction ($F_1 \times F_2$)	12	0.0575	2125.7513
Error	57	0.0000	
Total	79		

**Significant at 1% level.

4.3.4 Hardness of butter and its blends with 10%, 20% and 30% safflower oil

The results pertaining to the hardness of control butter and its blends with 10%, 20% and 30% safflower oil and changes in hardness during subsequent storage for 40 days are displayed in table 16.

It may be noticed from the table that the hardness of control butter and its blends with 10%, 20% and 30% safflower oil, as measured by penetrometer was found to be 59.8, 70.0, 88.5 and 129.75 units respectively. It may be further observed that the hardness of control butter and its blends remained constant during storage period of 40 days.

Statistical treatment of the data (table 17) obtained for hardness of control butter and its blends indicated that there was highly significant difference (P 0.01) in hardness with control butter being more harder, followed by 10%, 20% and 30% respectively. But it did not indicate any variation in hardness of control butter and its blends with 10%, 20% and 30% safflower oil respectively during the storage period.

Table 16: Hardness of control butter and its blends with 10%, 20% and 30% safflower oil at 15 ± 1°C (10^{-1} x m.m)

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	59.8	59.3	60.25	59.75	59.5
10%	70.0	69.75	70.25	69.75	69.5
20%	88.5	88.25	87.5	86.5	85.75
30%	129.75	126.25	125.5	122.5	121.25

Table 17: Anova table for hardness of control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean squares	F Ratio
Between trials	3	21.5458	4.2552
Between treatments (F_1)	3	2.1125	421.69**
Treatments	19	1709.8193	337.6895
Between storage periods (F_2)	4	13.6750	2.7008
Interaction ($F_1 \times F_2$)	12	2702.1750	533.6705
Error	57	5.0631	
Total	79		

** Significant at 1%

4.3.5 Spreadability

The results pertaining to spreadability of control butter and its blends with 10%, 20% and 30% safflower oil and subsequent changes during storage period are documented in table 18.

It may be seen from the table that the spreadability of control butter and its blends with 10%, 20% and 30% safflower oil was observed to be poor, fair, good, very good. It may be further noticed that the spreadability remained fairly constant during storage period of 40 days both in control butter and its blends.

4.3.6 Sensory evaluation

4.3.6.1 Flavour

The results pertaining to flavour scores of control butter and its blends and subsequent changes in flavour scores as recorded in hedonic scale are displayed in table 19.

It may be noticed from the table that the average flavour score of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 8.12, 8.25, 8.25, 8.25 respectively. It may be further observed that the flavour scores remained fairly similar during the storage period for 40 days.

Table 18: Spreadability of control butter and its blends with 10%, 20% and 30% safflower oil

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	POOR	POOR	POOR	POOR	POOR
10%	FAIR	FAIR	FAIR	FAIR	FAIR - POOR
20%	GOOD	GOOD	GOOD	GOOD	GOOD
30%	VERY GOOD	VERY GOOD	VERY GOOD	VERY GOOD	VERY GOOD

Table 19: Flavour scores of control butter and its blends with 10%, 20% and 30% safflower oil

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	8.12	8.12	8.25	8.0	8.0
10%	8.25	8.30	8.25	8.15	8.0
20%	8.25	8.25	8.25	8.15	8.15
30%	8.25	8.15	8.15	8.15	8.0

Statistical analysis of the data (table 20) did not show any significant difference in flavour scores observed either in control butter or in its blends. Further it did not recognise any variation in flavour scores during storage period.

4.3.6.2 Body and texture

The results pertaining to body and texture scores of control butter and its blends and subsequent changes in the storage periods for 40 days are presented in table 21.

It may be observed from the table that body and texture scores of control butter and its blends with 10%, 20% and 30% safflower oil were found to be 8.25, 8.30, 8.20 and 8.[illegible]0 respectively. It may be further observed that the body and texture scores remained fairly similar throughout the storage period for 40 days.

Statistical analysis of the data (table 22) did not recognise any significant difference in body and texture scores observed either in control butter or its blends. Further it did not notice any variation in body and texture scores during storage period.

Table 20: Anova table for flavour scores of control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean squares	F Ratio
Between trials	3	0,0752	1.3890
Between treatments (F_1)	3	0.1355	2.5040
Treatments	19	0.0394	0.7290
Between storage periods (F_2)	4	0.0308	0.5694
Interaction ($F_1 \times F_2$)	12	0.0183	0.3384
Error	57	0.0541	
Total	79		

Table 21: Body and texture scores of control butter and its blends with 10%, 20% and 30% safflower oil

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	8.25	8.15	8.15	8.15	8.0
10%	8.38	8.2	8.15	8.0	8.0
20%	8.15	8.15	8.20	8.25	8.10
30%	8.25	8.23	8.15	8.15	8.15

Table 22: Anova table for body and texture scores for control butter and its blends with 10%, 20% and 30% safflower oil

Source of variation	DF	Mean squares	F Ratio
Between trials	3	0.1690	2.5507
Between treatments (F_1)	3	0.0883	1.8559
Treatments	19	0.0409	0.8603
Between storage periods (F_2)	4	0.0301	0.6329
Interaction ($F_1 \times F_2$)	12	0.0327	0.6872
Error	57	0.0476	
Total	79		

4.3.6.3 Color and appearance

The results pertaining to color and appearance scores of control butter and its blends and changes that occured subsequently during storage period for 40 days are displayed in table 23.

It may be seen from the table that the color and appearance scores of control butter and its blends with 10%, 20% and 30% safflower oil were found to be 8.15, 8.25, 8.08 and 8.0 respectively. It may be further observed that the color and appearance scores remained fairly similar through out the storage period.

Statistical analysis of the data (table 24) did not indicate any significant variation in color and appearance scores observed either in control butter or its blends. Further it did not recognise any variation in color and appearance scores during storage period for 40 days.

Color and appearance scores for control butter and its blends with 10%, 20% and 30% safflower oil

Treatments source	Storage period (days)				
	0	10	20	30	40
Control	8.15	8.10	8.15	8.1	8.25
10%	8.25	8.23	8.15	8.2	8.1
20%	8.08	8.1	8.03	8.15	8.0
30%	8.0	8.1	8.0	8.05	8.0

Table 24: Anova table for color and appearance score for control butter and its blends

Source of variation	DF	Mean squares	F Ratio
Between trials	3	0.1030	2.0787
Between treatments (F_1)	3	0.227	1.1176
Treatments	19	0.0218	0.0770
Between storage periods (F_2)	4	0.0044	0.2157
Interaction ($F_1 \times F_2$)	12	0.0275	1.3539
Error	57	0.0203	
Total	79		

CHAPTER V

5. DISCUSSION

In this section the observations obtained on various aspects and their implications are critically discussed.

5.1 COMPOSITION OF BUTTER AND ITS BLENDS WITH SAFFLOWER OIL

5.1.1 Fat content

The results presented in table 1 indicates that the level of fat in butter (control) and its blends with 10%, 20% and 30% was found to be 80.05, 80.04, 80.03 and 80.05 percent respectively. It may be further seen that the level of fat either in control or its blends remained fairly constant throughout the storage period of 40 days (table 2). The level of fat observed in control and its blends in the present investigation is in agreement with IFA standards (1976) indicating proper control has been taken for maintaining level of fat in control and during blending of safflower oil in the butter and also during storage.

5.1.2 Moisture content

The results documented in table 3 reveals that the level of moisture in control butter and its blends was

observed to be 16.0, 15.97, 15.95, 15.95 percent respectively. It may be further noticed that the moisture level either in control butter or in its blends remained fairly stable during the 40 days storage period (table 4). The moisture content observed in the present investigation conforms to the PFA standards (1976) indicating that proper control has been ensured to prevent the loss of moisture through evaporation or increase in moisture levels through absorption from surroundings in control butter and during blending of safflower oil and also during the storage period for 40 days.

5.1.3 Curd content

The results shown in table 5 points that the curd content of control butter and its blends was found to be 2.05, 2.00, 2.02, 1.95 percent respectively. It may be further observed that the curd content, both in control and its blends with 10%, 20% and 30% safflower oil remained fairly constant during the storage period for 40 days (table 6). The observations obtained in the present investigation are fully in agreement with the PFA standards (1976). The curd percent which was lost during the replacement of butter fat at 10%, 20% and 30% levels with safflower oil were made out by adding calculated amounts of skim milk powder. So the curd content remained constant throughout the storage period of 40 days.

5.1.4 Salt content

The results indicated in table 7 shows that the salt content of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 1.95, 2.0, 2.05, 2.05 percent respectively. It may be further noticed that the salt content either in control butter or in its blends with 10%, 20% and 30% safflower oil remained fairly constant during the storage period for 40 days (table 8). The salt content observed in control and blends in the present investigation is in agreement with PFA standards (1976) pointing meticulous care was taken for maintaining the level of salt in control butter and during blending of safflower oil and also during the storage period.

5.2.1 Fatty acid profile butter (control)

It may be inferred from the data presented in table 9 that the average proportion of saturated and unsaturated fatty acids content was found to be 70.37, 29.63 percent respectively. The proportion of USFA viz. C18:1 and C18:2 was found to be 29.63. Among the saturated fatty acids, the proportion of short chain (C4-C8), medium chain fatty acids (C10-C14) and long chain fatty acids (C16-C18) was found to be 8.198,

15.78, 47.28 percent respectively. Comparision of data obtained in the present investigation, with those reported in literature is of little significance, since the milk fat is the most variable of all the milk constituents, and the fatty acid composition is subjected to marked changes due to species, breed, feed and season. However, the fatty acid composition obtained in the present study showed an augment in the general pattern with those of the average values reported by Hilditch and Sleightholme (1930), Hilditch and Thompson (1936), Hilditch and Jasperson (1943), Smith (1961), Jenson et al. (1962a), de Man (1964), Albonico et al. (1968), Cucurachi and Lotito (1968), Rama Murthy and Narayanan (1971).

5.2.2 Fatty acid profile of butter blends with 10%, 20% and 30% safflower oil

The data presented in table 9 indicates that the average proportion of saturated and unsaturated fatty acids in butter blends with 10%, 20% and 30% safflower oil was found to be 64.38 and 35.62 in 10% blend, 59.16 and 40.86 in 20% blend and 52.90 and 47.10 percent in 30% blend respectively. The proportion of USFA viz. C18:1 and C18:2 in the 10%, 20% and 30% butter safflower oil was found to be 35.62, 40.86, 47.10 percent respectively. Among the saturated fatty acids,

the proportion of short chain (C4-C8), Medium chain fatty acids (C10-C14) and long chain fatty acids (C16-C18) in all the three blends were found to be 6.26, 14.54, 43.30 in 10% blend, 5.52, 13.47, 40.18 in 20% blend and 5.36, 11.14, 36.71 percent in 30% blends respectively. It was evident from the data that the rPUFA content of butter blends with 10%, 20% and 30% safflower oil had shown an increase with a corresponding decrease in all other (saturated) fatty acids. This could be attributed to the safflower oil which was reported (Herb, 1960, Wilson et al. 1971, Swaminathan, 1974) to have high levels of linoleic acid (nearly 75% of the total fatty acids). Thus the replacement of safflower oil at 10%, 20% and 30% levels in butter blends has shown to contribute equally according to its amount with a corresponding decrease in all other fatty acids, viz. from C4:0 to C18:0.

The observations of the present investigation confirms the reports of Satish Kulkarni and Rama Murthy (1985) in a dairy blend containing 30% safflower oil. They reported an increase in C18:2 to tune of 20.2 percent in 30% butter-safflower blend from a meagre 1.0 percent initial value in butter. However, there are

no reports available as yet on the fatty acid contents of butter blends with 10% and 20% safflower oil for comparative assessment of the observations made during the present investigation. Since perceptible changes were observed in the ratio of SFA/USFA in the present investigation, it may be concluded that the incorporation of safflower oil in butter resulted in an increased ratio of SFA/USFA which was shown to have reduced the possible risk factors associated with chronic heart disease (Niyogy (1966), Kinsell et al. (1967), Thompson (1969), Weiss (1971), Fidenze (1972) and Horustra et al. (1973).

5.3 EFFECT OF BLENDING VEGETABLE OIL (SAFFLOWER OIL) IN BUTTER

5.3.1 Iodine value

Iodine value is an index of degree of unsaturation in the lipid system. Increase in Iodine value signifies an increase in the degree of unsaturation in the milk fat. In the context of incorporation of safflower oil in butter this study was undertaken to ascertain the extent of increase in Iodine value of butter blends with 10%, 20% and 30% safflower oil.

From the results obtained in the present investigation in table 10 and 11 the Iodine value of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 30.35, 41.26, 53.17 and 70.45 units respectively. It may be seen that there was a significant effect on Iodine value of butter blends with the addition safflower oil indicating an increased level of unsaturated fatty acids in butter blends. Thus confirming the observations reported in section 5.2.2 wherein an increase in SFA/USFA ratio has been observed. Further, it may be observed that there was no significant effect on the respective Iodine values of control butter and its blends during storage period for 40 days. Thus it may be concluded that butter blends with 10%, 20% and 30% safflower oil could be preserved to a period of 40 days without undergoing any change in the degree of unsaturation.

It is obvious that, the incorporation of safflower oil having 75% PUFA, there is every possibility for an increase in Iodine value. Kehar et al. (1956), Fjaervoll (1969), Kankare (1974) and Norris et al. (1976) reported similar observations for control butter. Though there are no published reports available as yet on the Iodine values of butter blends with 10% and 20% safflower oil. Satish Kulkarni and Rama Murthy (1987)

and Johansson et al. (1988) reported similar observations for butter, 30% safflower oil blend. Thus the observations reported in the present investigation are in confirmation with the observations reported in literature.

5.3.2 Peroxide value

Peroxide value is a measure for the autooxidation of fat. Higher peroxide value signifies the oxidative deterioration of fat. Oxidative rancidity is the major cause of flavour problem in PUFA rich butter during the storage. Since butter-safflower oil blends are rich in PUFA there is possibility for butter blends undergoing oxidative rancidity during storage. So this study was undertaken to evaluate the oxidative stability of butter-safflower oil blends during the storage period of 40 days.

From the observations of present investigation in table 12 and 13, it may be seen that the peroxide content of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 0.008, 0.011, 0.017 and 0.019 meq/kg fat respectively. The above observed values were well below the peroxide

values generally necessary for imparting oxidative flavour in butters. It has been reported that a peroxide value of 0.5-1.0 meq/kg fat is required for imparting oxidative flavour (Webb and Johnson). It may be further noticed from the observations in table 13 that the butter-safflower oil blends had not shown any significant increase in the peroxide value during the storage period for 40 days suggesting oxidative stability of butter-safflower oil blends during the storage period. Initiation of oxidation and resistance of fat to oxidation during storage is influenced by the presence of oxygen, copper content and exposure to light. However, in the present studies proper care was taken to minimize the contamination of copper, exposure to light and oxygen by proper packaging of the product. It has been reported that high quality butter fat retains its quality for at least for 6-12 months if properly stored (Anon 1985). Cadden et al. (1984a), (1984b) in their studies on PUFA rich butters reported no change in peroxide value in butters that were stored for one month. Thus, the observations obtained during the present investigation are adequately substantiated by the findings of other investigation. It may be concluded that butter blends with 10%, 20% and 30%

safflower oil could be preserved to a period of 40 days without any significant changes in oxidative stability.

5.3.3 Free Fatty Acids (FFA)

Free Fatty Acid (FFA) content reflects the extent of Lipolysis (Lipolytic rancidity or hydrolytic rancidity) in the lipid system. Lipolysis, regardless of the cause, seriously degrades the quality of butter by imparting rancid flavour. This study was undertaken to ascertain the FFA that develop during storage of butter blends for 40 days.

From the observations of present investigation in table 14 and 15, it may be seen that the FFA content of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 0.214, 0.316, 0.384, 0.407 respectively. These were found to be well below the permissible limit under PFA (1976). Further no changes in FFA content of both the control butter and its blends were seen during the storage for 40 days indicating absence of Lipolytic activity. Schwartz (1954), Harper and Could (1959) reported that heating at 80°C for 20 sec is sufficient to destroy all lipases of milk which are responsible for lipolytic rancidity. Therefore, no lipase activity could be

expected in butter and its blends which have been prepared from pasteurised cream. However, the levels of FFA observed in the present investigation may be due to pre-manufacture lipolysis arising from the uptake from cream of FFA liberated by the native milk enzyme (Downey, 1975) and also to FFA content of safflower oil. Similar observations in FFA contents in PUFA rich butters were reported by Cadden et al. (1984a) (1984b). Thus, the observations of the present investigation are in agreement with the observations reported in the literature. Present studies signify that incorporation of safflower oil at 10%, 20% and 30% levels in butter had not shown any perceptable increase suggesting the absence of lipolytic rancidity in the products.

5.3.4 Hardness

Hardness of butter refers to the ratio of saturated and unsaturated fatty acids. Increased hardness indicates the presence of higher amounts of saturated fatty acids. Unsaturated fatty acids gives softness to butter. This study was undertaken to study the effect, of safflower oil incorporation at 10%, 20% and 30% in butter on hardness.

From the observations obtained in the present investigation in table 16, the hardness of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 59.8, 70.0, 88.5, 129.75 units respectively. It may be seen that there was significant effect on hardness of butter safflower oil blends with an increase in incorporation of safflower oil indicating an increased level of unsaturated fatty acids. The decrease in hardness of butter-safflower blends could be attributed to an increase in unsaturated fatty acids (section: 5.2.2 & 5.3) which increased the liquid fat and correspondingly the softness of butter. It may be further seen (table 17) that the hardness of control butter and its blends remained fairly constant indicating proper control in moisture content and storage temperature (section 5.1.2) during the storage period. Similar observations on hardness resulting from PUFA rich butters were reported by Kapsalis et al. (1963), Bachanan and Rogeri (1973), Scott et al. (1978) and Satish Kulkarni and Rama Murthy (1985), (1987), (1988).

The observations obtained in this investigation are in confirmation with the observation reported in

the literature. Thus, it may be concluded that an increase in the level of PUFA in butter tends to make the butter softer.

5.3.5 Spreadability

From the observations obtained in the present investigation in table 24, the spreadability of butter and its blends with 10%, 20% and 30% safflower oil as measured physically by objective tests immediately after the samples were taken from refrigerator without thawing the samples was found to be Poor, Fair, Good and Very Good respectively. It may be further seen that there was no significant change in spreadability during the storage period. Increased spreadability in the butter blends could be attributed to an increased USFA content which remains in liquid state even at low temperatures (5°C). This explains the reason for increased spreadability of butter blends. It has been reported that an increase in Iodine value results in an increase in spreadability (Hill and Palmer 1938, Dixon 1964) indicating indirectly in enhancing levels of USFA. Similar observations were reported by Satish Kulkarni and Rama Murthy (1987), (1988), in their studies on butter-vegetable oil blends. So the observations

of present investigation are in agreement with the observations reported in the literature.

Thus, it may be concluded that the incorporation of safflower oil not only enhanced the PUFA content (section 5.2.2) but also overcame the problem of poor spreadability of butter which is generally observed by connoisseur of butters. So the incorporation of safflower oil upto a level of 30% can circumvent the problem of poor spreadability of butter when drawn directly from the refrigerator at low temperature.

5.3.6 Sensory evaluation

5.3.6.1 Flavour

From the observations of present investigation in table 19, it may be noticed that the average flavour scores as measured on hedonic scale, of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 8.125, 8.25, 8.25 and 8.25 respectively. It may be further observed in table 20, that no perceptible change in the flavour score of butter and its blends was observed during the storage period for 40 days It may be inferred from the observations that a butter blend similar in flavour characteristics to that of

control butter could be manufactured by incorporating safflower oil upto 30% level. There was no change in the flavour during the storage period of 40 days which may be attributed to the use of completely deodourised safflower oil and also to the absence of Oxidative and lipolytic rancidity (5.3.2 and 5.3.3). The judges were unable to perceive any change in the flavour of butter and its blends. Similar observations regarding flavour changes in butter-vegetable oil blends were reported by Miller (1968), Bachanan and Rogeri (1973), Hehira et al. (1976), Arsov (1984), Satish Kulkarni and Rama Murthy (1985) (1987) (1988).

Thus it may be concluded that the addition of safflower oil at 10%, 20% and 30% level in butter had no effect on the original flavour of butter.

5.3.6.2 Color and Appearance

From the observations of the present investigation in table 23, it may be noticed that, the average color and appearance scores of control butter and its blends with 10%, 20% and 30% safflower oil was found to be 8.15, 8.25, 8.08 and 8.0 respectively. It may be further seen that there was no change in color and appearance during storage period of 40 days as indicated by

the score in the table 24. Further there was no significant difference in the scores of color and appearance compared to that of control butter statistically. But the marginal decrease in the scores of color and appearance observed for the blend may be attributed to the effect of incorporation of safflower oil in butter which resulted in lighter color. However, the score was within the acceptable limit which was also observed by various authors in their studies on butter-vegetable oil blends (Miller 1968, Bachanan and Rogeri (1973), Satish Kulkarni and Rama Murthy (1985) (1987) (1988) and Biernorth et al. (1986).

Thus it may be concluded that the higher level of safflower oil incorporation had no significant effect on the acceptability of butter blends with respect to color and appearance.

5.3.6.3 Body and Texture

From the observations of the present investigation in table 21, it may be seen that, the average body and texture scores of control butter and its blends were found to be 8.25, 8.30, 8.20, 8.30 respectively. It may be further observed that the butter blends retained its body and texture throughout the storage period of 40 days as indicated by body and texture scores wherein

no difference was discerned in the score during the storage (table 22). It may be inferred from the observations that a butter blend similar in body and texture characteristics to that of control butter could be manufactured by incorporating safflower oil upto 30% level. It was found (from the preliminary studies on the extent of incorporation of safflower oil) that, butter blends upto 30% safflower oil incorporation could able to retain their body and texture. Beyond 30% level, it was observed that the butter blend was sloppy and had excessive spreadability which was found to be non-advantageous. So the present study was restricted upto 30% level. However, Judges observed that the body and texture were acceptable when compared to ordinary butter, though they have observed little softness with increased level of incorporation. Miller (1968), Arsov (1984), Biernorth et al. (1986) in their studies on the sensory characteristics of butter blends reported similar observation on the body and texture characteristics.

Thus it may be concluded that the incorporation of safflower oil in the butter had no significant effect on the body and texture of the butter blends.

5.4 COMPARATIVE - COST STUDIES

Comparative costs of control butter and its blends are given below:

		Rs. ps.
1. Cost of butter fat per kg	..	58.00
2. Cost of SAFFOLA per kg	..	44.00
3. Cost of butter fat + 10% safflower oil	..	56.60
4. Cost of butter fat + 20% safflower oil	..	55.20
5. Cost of butter fat + 30% safflower oil	..	53.80

It may be seen from the above observations that the butter fat on 100% basis is costlier than the vegetable oil (refined safflower oil). So the replacement of safflower oil at 10%, 20% and 30% has resulted in a marginal decrease in the cost of the product. Further, 30% level has least cost of production. The other constituents of butter were similar in both control butter and its blends. Thus, it may be concluded that incorporation of safflower oil has resulted in a marginal decrease in the production cost of the blends. The cost of 30% level of safflower oil incorporation prooved to be minimum and was found to be economical.

CHAPTER VI

6. SUMMARY

This study was undertaken to study the feasibility of incorporation of safflower oil at 10%, 20% and 30% levels in butter to enhance the levels of PUFA and its effect on physical and chemical characteristics such as sensory characteristics, hardness, spreadability, I.V, peroxide value, FFA content and fatty acid profile of resultant butter blends and subsequent changes during 40 days of storage period and also the economic feasibility of the blends. Butter was prepared from mixed milks, safflower oil sold in the brand name of 'Saffola' was used at 10%, 20% and 30% levels in the butter. Butter without any oil was also prepared as control.

Butters with 10%, 20% and 30% safflower oil had same proximate composition of 80% fat, 16% moisture, 2% curd and 2% salt as that of control butter. The fatty acid profile of butter blends recognised a significant increase in PUFA content (18:2) with a corresponding decrease in all other fatty acids compared to the control butter. The PUFA content of control butter and 10%, 20% and 30% butter safflower oil blends was found to be 2.13 $\pm$ 0.072, 9.52 $\pm$ 0.8113, 16.756 $\pm$ 0.7391 and 23.56 $\pm$ 0.9261.

Iodine value significantly (P 0.01) increased with higher level of (10%, 20%, 30%) oil incorporation as compared to control butter. Average Iodine values of control butter, and 10%, 20% and 30% oil incorporation were found to be 30.35, 41.26, 53.17 and 70.45 respectivel Further storage period from 0 to 40 days did not effect significantly the I.Vs of both control butter and its blends.

Peroxide values of butter blends with 10%, 20% and 30% safflower oil had increased more than that of control butter, but was found to be non-significant. Increased oil incorporation had shown a slight increase in peroxide value. The average peroxide value of control butter and its blends were found to be 0.008, 0.111, 0.017 and 0.019 meq/kg/fat respectively. Further, storage period from 0 to 40days had no significant effect on the peroxide values of both control butter and its blends indicating the absence of oxidative flavours.

FFA content (values)were higher in butter incorporated with 10%, 20% and 30% safflower oil than control butter. Increased level of oil incorporation had resulte in an increase in FFA value but this was under permissible limit to impart lipolytic rancidity. The average FFA

values of control butter and its blends were found to be 0.214, 0.316, 0.384 and 0.407 respectively. Further storage period from 0 to 40 days had not resulted in any significant effect on the respective FFA values of both control butter and its blends suggesting the absence of lipolytic activity.

A decrease in hardness was observed with an increase in the levels of safflower oil, the product was soft enough to retain its body and texture and it did not deter the blends to be ranked similar to control butter. The average values for hardness for control butter and its blends were found to be 59.8, 70.0, 88.50 and 129.75 respectively.

Spreadability of butter blends had shown a significant change with an increase in the level of oil incorporation. Spreadability was at its best at 30% level of oil incorporation. Beyond 30% level, butter was sloppy and excessive spreadability (fluidity) was observed which was found to be non-advantageous and the product failed to keep it's characteristics body and texture.

Sensory characteristics

Butter blends with 10%, 20% and 30% had flavour scores similar to that of control butter, oil incorpo-

ration had no significant effect on flavour. Storage period had no significant effect on flavour scores of both control butter and its blends.

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Color and appearance scores were not significantly affected by the level of oil incorporation. Color and appearance score remained fairly similar (though lighter, in color, it was acceptable) with increased level of oil incorporation. Colour appearance score of control butter and its blends remained fairly stable through out the storage period from 0 days to 40 days.

Body and texture scores were found to be non-significant in control butter and its blends level of oil had no significant effect on body and texture. Storage period from 0 to 40 days did not show any significant effect on body and texture in both control butters and its blends.

Storage of control butter and its blends for 40 days did not indicate any perceptible changes in Iodine value, peroxide value, FFA content, hardness and spreadability, indicating the absence of oxidative flavours and lipolytic or hydrolytic rancidity in the blends.

Thus, it may be inferred from above observations that a butter blend, similar in flavour, body and texture and color and appearance and readily spreadable at even low temperature (5 $\pm$ 1°C), compared to ordinary butter could be manufactured by incorporating safflower oil upto a maximum level of 30%. The present study recommends that safflower could be incorporated upto 30%, since it was found to be economical and physically advantageous. Beyond 30% level, it was assessed that the blends failed to keep their body and texture and had excessive spreadability which was found non-advantageous.

The cost of product per kg of butter fat incorporated with 10%, 20% and 30% safflower oil was marginally lower (Rs.56.60, 55.20, 53.80) than the control butter (Rs.58.00) on 100% fat basis. Further, increased levels of oil incorporation decreased the cost of product. Butter blends with 30% safflower oil incorporation had least cost of production.

APPENDIX

Procedure for butter manufacture

Milk

Separation

Cream

Pasteurisation

Churning

Washing

Salting and working

Packaging and storage

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