Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 08, pp.35543-35551, August, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

DEVELOPMENT OF A LOW COST MAYONNAISE PRODUCT CONTAINING AVOCADO PULP

***Shiby, V. K., Samyukta, S. and Pandey, M. C.**

Freeze Drying and Animal Products Technology Division, Defence Food Research Laboratory, Mysore-570011

ARTICLE INFO

Article History:
Received 15th May, 2016
Received in revised form
06th June, 2016
Accepted 11th July, 2016
Published online 20th August, 2016

Key words:

Mayonnaise,
Avocado,
Emulsification,
Phytonutrients.

ABSTRACT

Background: Avocado pulp having appreciable phytochemical properties was selectively used as a fat replacer and also as a source of natural antioxidant in formulating a new mayonnaise product to improve its nutraceutical value and reduce cost of production.

Results: This product was found to be comparable to the Egg yolk (EY) formulated sample (experimental control) organoleptically. Incorporation of avocado pulp upto 50% of the emulsifier (EY) did not impart any bitterness and had improved physical properties such as increased color tonality with slightly lesser chroma values, lower thermal and non thermal creaming, homogenous and compact microstructure. The EY: Avocado (50:50) sample had comparable viscosity vis-à-vis the EY control. The avocado mayonnaise had similar carotenoid content (1.4-1.8µg/g) and 12 % reduced fat content than Egg Yolk mayonnaise. The mayonnaise samples prepared with avocado pulp: EY in the ratio 50:50 had shown comparable emulsion properties with the commercial sample. Samples formulated with 75 % and 100% avocado had poorer microstructure and emulsion properties than control (100% EY). The cost reduction achieved in 50% formulation was to the extent of 10 %.

Conclusions: Avocado mayonnaise is a product with lower cost and good sensory acceptability. It offers a suitable product for value addition of avocado where it is sold at cheaper rates.

Citation: Shiby, V. K., Samyukta, S. and Pandey, M. C. 2016. "Development of a low cost mayonnaise product containing avocado pulp", *International Journal of Current Research*, 8, (08), 35543-35551.

INTRODUCTION

The avocado is a medium energy dense (1.7 kcal/g) fruit which provides about 20 essential nutrients. The avocado is one of the few cultivated succulent fruits in which fatty oil is characteristic and predominant dry constituent. It mainly contains mono unsaturated fats like oleic and palmitoleic acids and also omega-6 poly unsaturated linoleic acid. Fat provides about 75% of the calories. Avocados also contain a variety of vitamins, minerals and phytochemicals such as lutein, phenolic antioxidants, and phytosterols associated with numerous potential health benefits. They have the highest fiber content of any fruit—including 75% insoluble and 25% soluble fiber. It is rich in B complex and vitamins A, E and K. It is extremely rich in iron, copper, magnesium, manganese and potassium. Along with high tannin content it is extremely rich in many polyphenolic antioxidants like lutein, zeaxanthin, carotenes and cryptoxanthin. Avocado has a nutrient boosting effect. This means that it enables the body to absorb more of alpha and beta carotene and lutein if the fruit is eaten with food (Unlu *et al*., 2005) Sensory and nutritional characteristics of avocado are worldwide recognized, and it has been mentioned that the oil of this fruit is qualitatively compared with the olive oil. Both of these oils have been described with potential benefits to reduce cardiac risks under its consumption. The excellent flavor end exquisite sensation in the mouth makes it *nature's butter.* Avocado pulp oxidizes very quickly due to the activity of the *polyphenol-oxidase*, PPO, enzyme. Methods to preserve avocado pulp have been sought for long time; any method must inhibit the polyphenoloxidase enzyme and retain the sensory and nutritional characteristics of the fresh product. Thermal treatments are not recommended because they reduce the excellent sensory characteristics and increase the nutritional losses of the fruit. Some research has been carried out incorporating avocado pulp in ice cream resulting in better texture and preferable taste. Improved nutritional content, acceptability, ease of preparation and low cost of home baked products have been reported by using avocado puree as fat replacer in cookies (Wekwete and Navder, 2008). Mayonnaise is oil in water emulsion and egg components are its emulsifier. Egg contributes to the emulsification, stabilization, flavor and color of mayonnaise. Egg possesses high nutritional value and is comprised of 75 % water, 12.5 % protein, 12 % fat, and a small proportion of carbohydrate (Maghsoudi, 2004). Both egg yolk and egg white contain several components, each of which

****Corresponding author: Shiby, V. K.***
Freeze Drying and Animal Products Technology Division, Defence Food Research Laboratory, Mysore-570011.

possesses emulsifying activity (Mine, 1998; Drakos and Kiosseoglou, 2006; Drakos and Kiosseoglou, 2008). Although egg possesses excellent emulsifying ability, concerns about high blood cholesterol are developing. Realizing they can contribute to their health, people eat much more knowledgably. So there have been done several studies on removing egg in mayonnaise. Use of wheat proteins, Canola proteins &milk proteins in native and hydrolyzed forms have been reported for emulsifying functionality to stabilize mayonnaise (Aluko and McIctosh, 2005; Ghoush *et al*., 2008; Goankar *et al*., 2010). Some researchers recommended the use of soy flour at high levels in mayonnaise for replacement of egg. Obesity is a major health concern because it is implicated in development of many chronic diseases. As per dietary guidelines the total fat intake should be 25 percent to 30 per cent of total calories, with most fats coming from sources of PUFA and MUFA. The average composition of mayonnaise holds 50-60% olive oil for emulsification.

According to American Heart Association avocado can help consumers to meet dietary guidelines to have fats low in saturated fat and cholesterol. The partial replacement of olive oil and egg with avocado pulp and stabilisation of the avocado mayonnaise using suitable hurdles is a novel attempt to arrive at a healthier substitute for mayonnaise as avocado is the only fruit rich in MUFA.

This study was undertaken to ascertain the functionality of avocado pulp as a fat replacer and a source of phytonutrients in mayonnaise. It was also of interest to compare the similarities and differences of mayonnaise substitute made with this readily available natural fruit puree with a commercially available mayonnaise. Our objective, therefore, was to determine the effectiveness of substituting egg yolk with avocado pulp and reducing olive oil content in the blend on the physical, sensory and emulsification properties of mayonnaise.

MATERIALS AND METHODS

Materials: Extra Virgin Olive oil, egg, vinegar, salt, sugar, and mustard were provided from a local supermarket. Gum Arabic was purchased from Sigma Aldrich Co., Whey protein concentrate was purchased from Pristine organics, Bangalore

Preparation of mayonnaise: Mayonnaise sample (EY control) was prepared using EY with 55 % olive oil in the blend. The experimental samples were prepared by partially or fully replacing Eggyolk with avocado pulp (75:25, 50:50, 25: 75 and 0:100) and reducing olive oil content from 55 to 43 percent. A market sample of mayonnaise was procured for comparison in which whole egg is used (EC commercial). The ingredient formulations for experimental samples containing avocado are shown in Table 1. 75% of the formulations was comprised of varying combinations of eggyolk, avocado pulp and olive oil. Other ingredients like mustard, Black pepper, garlic powder, chilli flakes, salt, gum, WPC and sugar were kept constant in all formulations.

pH of mayonnaise: The pH of the mayonnaise samples was measured using pH meter (Model-PC 510 pH, M/s Eutech Instruments, Singapore) with 5 g of mayonnaise samples which were homogenized with 25 ml deionized water (No and Meyers, 2004).

Color measurement: Color measurement of mayonnaise samples was carried out. Color measurements were carried out by means of a colorimeter ColorQuest XE (HunterLab, Reston, USA) using D65 illuminant and observation angle of 10 in terms CIELAB parameters, L*(lightness, 0 = black, 100 = white), a *(redness and greenness) and b* (yellowness and blueness). The instrument was calibrated against a standard white reference tile (L = 90.55, a = -0.71, b = 0.39).

Hue and chroma angles were calculated using Eqns. 1 and 2 respectively

$$\text{Hue} = \tan^{-1}\frac{b}{a}, \text{ ....Eqn (1)}$$

$$Chroma = \sqrt{a^{*2} + b^{*2}} \text{ ....Eqn (2)}$$

Thermal and non thermal creaming

Non-thermal and thermal creaming values of mayonnaise samples were determined at a periodic interval over a storage period of 3 months, in accordance to the method reported by Rahamati *et al*. (2012) with little modifications. To determine the non-thermal creaming value at room temperature, 8 g of mayonnaise samples were transferred into cylindrical plastic containers and centrifuged at 5,000 g for 20 min. The emulsion creaming at room temperature was determined by the following equation:

$\%H = H/H_0 \times 100$

where, %H is the percentage of creaming, H is the height of the cream separated from emulsion in mm and H_0 is the initial emulsion height in the container in mm. Thermal creaming was determined by a similar procedure except that the containers were incubated at 80 °C for 20 min, prior to centrifugation (Rahmati *et al*., 2012).

Optical microscope observation

Optical microscope observations of the mayonnaise samples were performed to compare the microstructure of the emulsions by using a light microscope (Olympus BX41) of magnification range 0-100x. The system is equipped with a digital camera to prepare micrographs. One drop of each sample was transferred on a glassy flat slide without dilution and covered by a cover slip to obtain micrographs

Viscosity

Viscosity measurement of mayonnaise samples were carried out in a Brookfield Digital Viscometer (M/s Brookfield Engineering Company, MA, USA), model LVDV-E with spindle nos. 3 and 4 at 25±1 °C.

Determination of fat and carotenoids in mayonnaise samples

Total Fat content was estimated using Direct Solvent extraction technique with petroleum ether. Total carotenoid was determined using solvent extraction method (Yen *et al*., 2008; Prakash *et al*., 2004). 5g sample was taken in a 250ml volumetric flask and 40ml acetone was added. Flask was placed on a stirrer and stirring was continued till the residue became colourless to extract maximum carotene. The acetone extract was filtered and petroleum ether (100ml) was added along with a squeeze of sodium sulphate (to absorb any moisture) were placed in a separating funnel and shaken for 1min. The yellow upper layer was carefully transferred into a 250ml standard flask and the lower layer was drained to another separating funnel. It was again extracted using petroleum ether and the yellow upper layer was collected. Same procedure was repeated twice and collected the yellow layer was made up to 250ml volume mark and an aliquot from the solution was taken for optical density measurement. Optical density was measured in terms of absorbance in Lamda-25 UV-Visible spectrophotometer (Perkin Elmer, Singapore) at 452nm.

Calculation

Total carotenoid = $\frac{OD\ value \times Volume\ made\ up \times 1000}{weight\ of\ sample \times 2\ 5\ 0}$

Sensory evaluation

Sensory evaluation by a semi-trained panel of 20 members was carried out on freshly prepared mayonnaise samples. The coded samples were randomly presented to each panelist, with a rest period between sample presentations to minimize sensory fatigue. Sensorial sessions were conducted in an air-ventilated room under white light. Nine characteristics such as flavor, thickness, spoonability, body and creaminess, color, taste, appearance, acceptability and aftertaste of mayonnaise were scored on a 9-point hedonic scale (Rahmati *et al*., 2012).

Statistical Analyses

Three samples from each of the seven batches for each treatment (control and two variations) were used for all measurements. All data were analyzed using SYSTAT 13 software and were subjected to analysis of variance with Fisher's least significant test for mean separation at 0.05 level of probability.

RESULTS AND DISCUSSION

The composition of the avocado mesocarp, which is the edible part of the fruit, varies with different cultivars and harvest season. Representative values for Hass variety used in this study were as follows: dry matter, 19.18 to 30.29 %, fat 8.3 to 16.75 %, protein 2.1 to 2.3 %, carbohydrates 6.8 to 8.1 %, mineral ash 0.7 to 1.2 %, and the higher values belonging to the fruits harvested toward the end of the season.

pH of mayonnaise

The pH values of mayonnaise samples presented in Table 2. It was found that pH of freshly prepared mayonnaise samples were in the range of 3.7 to 4.3 indicating the mayonnaise to be acidic in nature. ANOVA study reveals that pH of all the mayonnaise samples changed insignificantly (p=0.08203) based on the incorporation. The incorporation of avocado pulp slightly increased the pH values. However avocado mayonnaise falls in the category of high acid foods with pH < 4.5 which supposedly prevented the growth of food spoilage microorganisms.

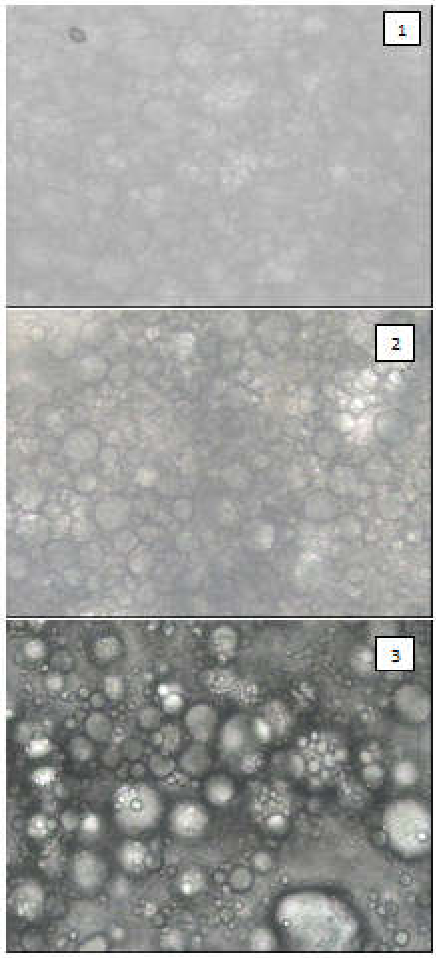

Figure 1. Microsturcture of (1) EY control (2) EY: avocado (50:50) and (3) EY:avocado (0:100) at 10x magnification

Microstructure, stability and viscosity

Mayonnaise is typical oil in water emulsion stabilized with egg yolk. Manufacturers usually try to reduce oil content of mayonnaise as much as possible within the limits of food regulations of the country the mayonnaise will be sold in. This is because the oil is usually the most expensive component of mayonnaise. Earlier reports suggest that by reducing oil content the density of oil droplets reduces. This means that the interactions between droplets are weakened and emulsion becomes less stable. In the absence strong intra droplet interactions low fat emulsions separate under gravity. Figure 1 demonstrates microstructure of the samples. YC, EC, 50 % avocado, and 100% avocado samples. 50% Avocado sample had homogenous and pack microstructures and less homogenous structure was observed for 100 % Avocado. It can be understood from the observations, although 25 % Avocado and 50 % avocado samples had less amounts of yolk, their microstructures did not have considerable difference with EC.

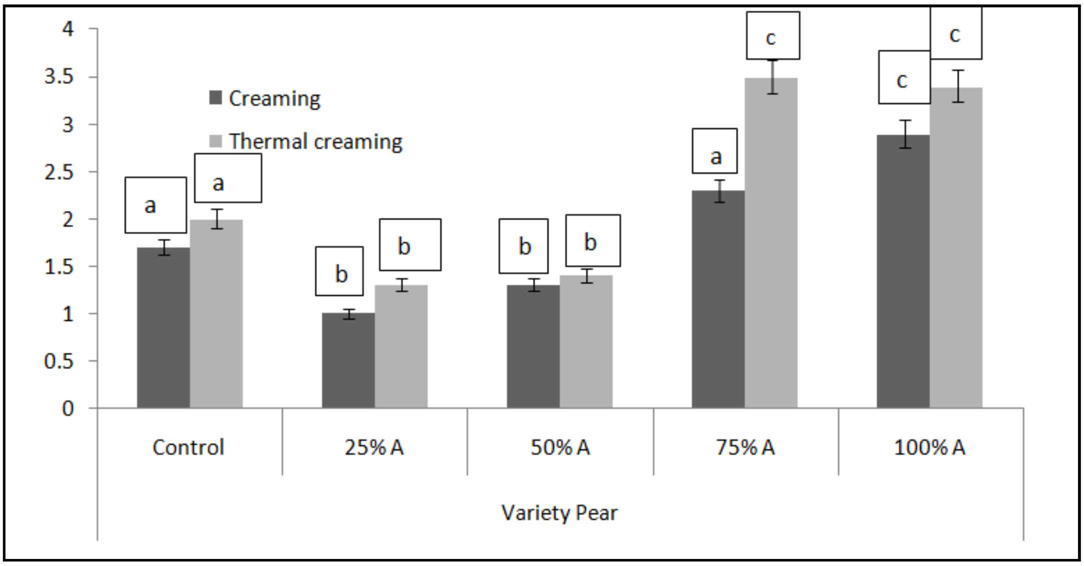

Figure 2. Creaming and thermal creaming of EY control and experimental samples containing varying levels of Avocado pulp

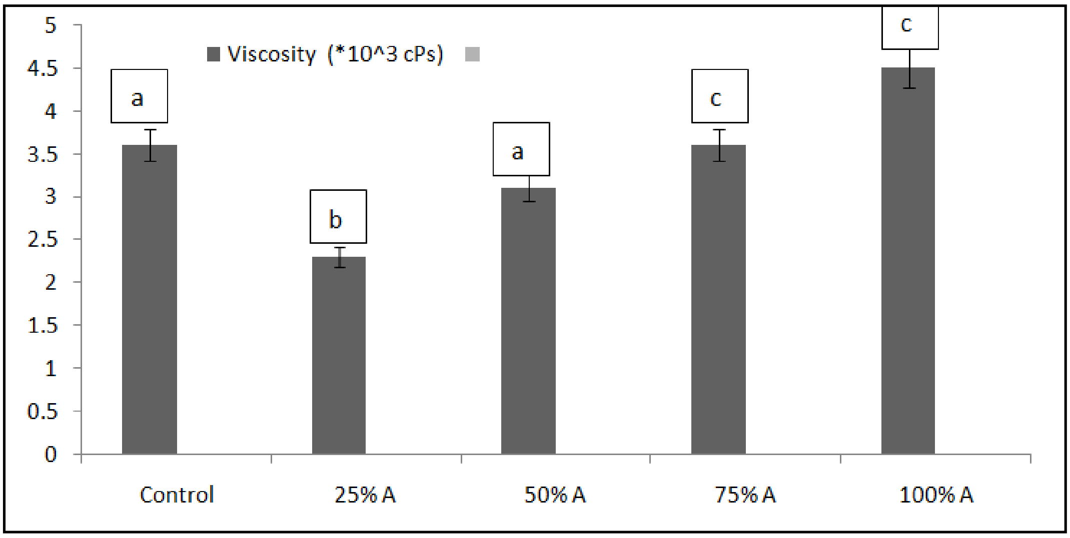

Figure 3. Viscosity of EY control and experimental samples containing varying levels of Avocado pulp

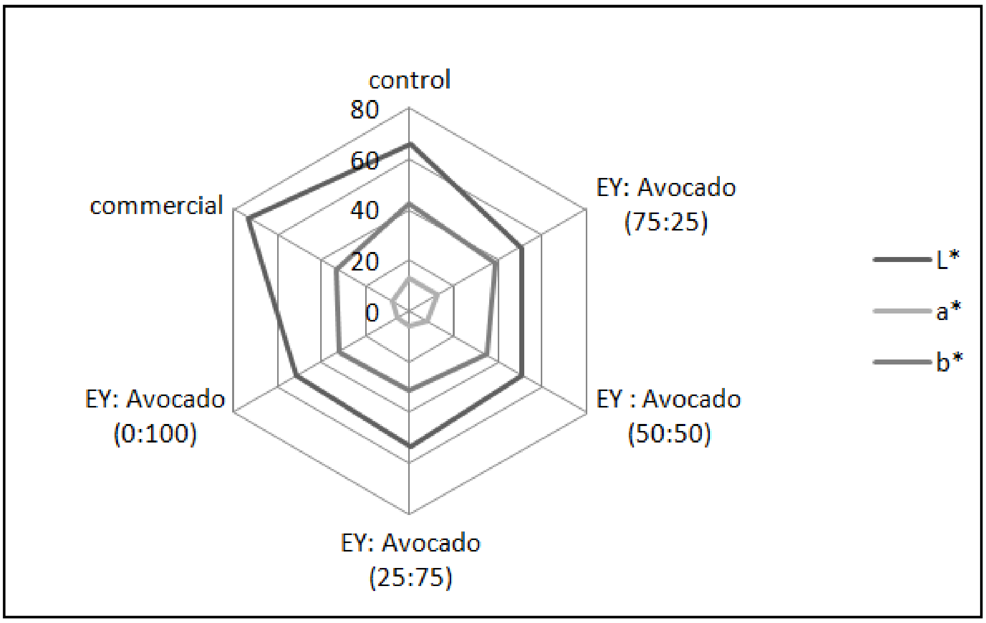

Figure 4. Colour values of of EY control, commercial EC and experimental samples containing varying levels of Avocado pulp

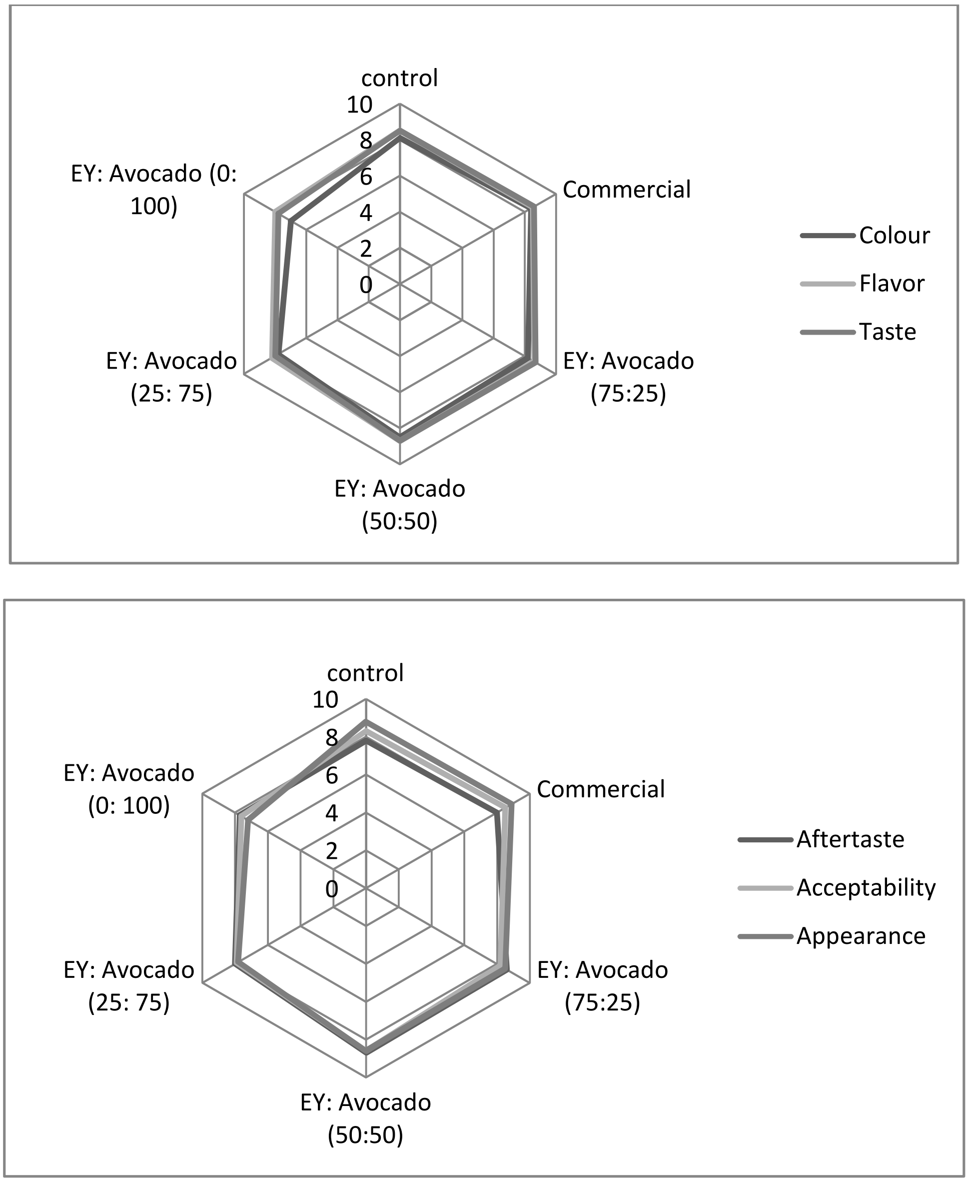

Fig. 5. Non Textural sensory attributes of EY control and mayonnaise containing varying proportions of avocado pulp

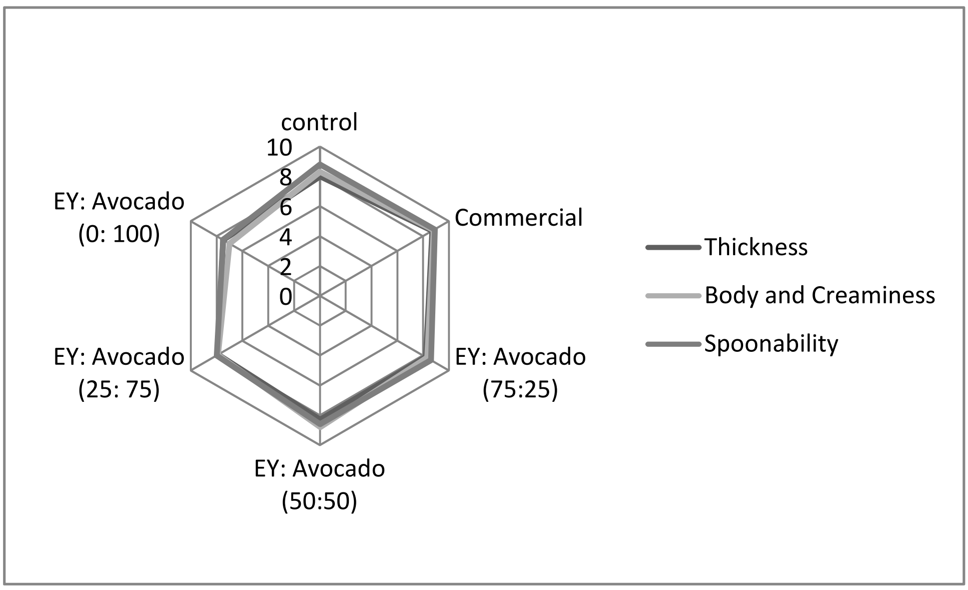

Fig. 6. Textural sensory attributes of EY control and mayonnaise containing varying proportions of avocado pulp

Table 1. Ingredient composition for mayonnaise with varying levels of avocado pulp

Ingredient (%)	EY : avocado (75:25)	EY : avocado (50:50)	EY : avocado (25:75)	EY : avocado (0:100)
Mustard	0.49	0.50	0.49	0.49
Black pepper	0.49	0.50	0.49	0.49
Garlic powder	0.49	0.50	0.49	0.49
Chilli flakes	0.49	0.50	0.49	0.49
salt	1.28	1.29	1.28	1.28
Egg yolk	23.69	15.38	7.40	0.00
Avocado	7.40	15.38	23.69	31.10
Lime juice	7.90	7.94	7.90	7.90
olive oil	43.44	43.65	43.44	43.44
Sugar	1.68	1.69	1.68	1.68
WPC	3.46	3.47	3.46	3.46
Gum	0.30	0.30	0.30	0.30

Table 2. pH, Hue and Chroma values of avocado mayonnaise samples

	Hue	Chroma	pH
Control	76.65± 0.1	39.33±0.2	3.72±0.02
EY: Avocado (75:25)	75.11±0.11	34.02±0.15	4.29±0.03
EY : Avocado (50:50)	74.31±0.2	32.76±0.1	4.24±0.01
EY: Avocado (25:75)	73.26±0.12	32.66±0.08	4.21±0.03
EY: Avocado (0:100)	72.84±0.31	32.23±0.13	4.32±0.04

All values shown are mean ±sd of triplicate measurements. Staistically significant differences are denoted by different superscripts in the same column

P2 (50% avocado) exhibited a uniform distribution of small oil droplets indicating better stability whereas 100% avocado sample was a dispersion of very big oil droplets with non uniform size and distribution. The use of sucrose stearate in emulsions containing 50 or 55 % oil for better emulsion microstructure has been reported (Tung and Jones, 1981). Creaming and thermal creaming data are shown in Figure 2. Creaming refers to phase separation due to upward rise of fat globules due to differences in density between the dispersed and the continuous phases (McClements, 2009). For large globules, the extent of creaming will depend upon the duration of storage time of the product (Mangino, 1994). Thermal creaming describes accelerated flocculation that results in more creaming caused by the high temperature samples were placed in. The most stable sample was 50% avocado and stability values decreased with avocado content more than 50 %. The major mechanism preventing droplet flocculation, in protein stabilized emulsions is electrostatic repulsion and it occurs between emulsion droplets with electrically charged surfaces, which may occur in emulsions due to the adsorption of ionic or ionizable components such as surfactants, phospholipids, proteins or polysaccharides (McClements, 2009). After being stored in 2 °C for 3 months, 100 % avocado showed the least stability value compared to those of the others and a layer of oil was clear after 10 days of storage but there was no marked oil separation in the case of other samples.

Viscosity values are presented in Figure 3. Results showed that 100% avocado sample had maximum viscosity likely due to high apparent viscosity of the pulp, which is a pseudoplastic fluid. Hence the viscosity increased significantly ($p<0.05$) as the level of avocado pulp increased .But the emulsion stability was not directly proportional to the pulp content. Upto 50% level, the emulsion showed particles of smaller size, improved surface contact area and friction force between drops compared to samples containing higher levels of pulp. Not affecting viscosity and stability up to 50 % replacement statistically, avocado can be employed in mayonnaise formula successfully.

The viscoelasticity of mayonnaise made with egg yolk reaches a maximum very quickly after preparation, compared to emulsions made with mesquite gum or with meat or soy proteins due to the flocculation of adjacent oil droplets to form a network, essentially a weak gel (Kiosseoglou and Sherman, 1983). The strength of the interactions between oil droplets depends on the van der Waals attractions, which are balanced to some extent by electrostatic and steric repulsion. The quality of the emulsion will depend on the right balance between these forces: too strong an attraction will pull the droplets together causing the aqueous phase to be squeezed out and promoting coalescence of the droplets. Too strong a repulsion will allow the droplets to slip easily past one another. This will produce an emulsion with low viscosity and prone to 'creaming' as the oil droplets settle into their minimum volume allowing the water to drain out. Despite concerns about its cholesterol content, egg yolk is still the most commonly used emulsifying agent because of its outstanding qualities both for forming the emulsion and for the way that egg-yolk emulsions flocculate to give the correct texture. Liquid egg yolk is itself an emulsion comprising hydrophobic granules suspended in an aqueous phase containing most of the protein (Harrison and Cunningham, 1985). It contains a complex mixture of components including the phospholipid lecithin and a number of proteins and lipoproteins including lipovitellin, lipovitellinin and livetin. These components are thought to be essential to the emulsion-forming properties of egg yolk but are not themselves as effective as fresh egg yolk either singly or together. The present study shows that avocado pulp can be a healthier substitute for EY in mayonnaise and the quantity of olive oil required for forming the emulsion decreased with increase in avocado content.

Color analysis results

As indicated in Figure 4, EC commercial sample was the lightest sample with a higher L-value probably due to the greater proportion of added egg white. As more amounts of avocado were used the value of L* decreased. Another factor affecting lightness of emulsions is particle size. The color of emulsions changes from a bright white color to an increasingly gray color as the droplet size increases and droplet sizes in this study confirm this report (McClements and Demetriades, 1998; Worrasinchai *et al*., 2006; Mun *et al*., 2009). Surely, this attribute affects mayonnaise appearance. In the case of a-value, 25 %, 50 %, avocado samples showed no significant difference with sample EC. In terms of b-value, 75% and 100 % substitution caused the lowest values, probably due to the most amount of avocado pulp affecting the color. High b-value of YC was due to higher content of yolk which contains pigments. There was no significant difference in b*value of 25 % avocado, 50 % avocado. In addition yellowness (b*) of EC was lower than the others due to the proportion of egg white in this sample decreasing yellowness. 100% avocado sample appeared greener compared to the yolk control, significantly different in colour. Upto 50% avocado level, there was no significant difference in colour. 25% and 50% samples had similar L* and a* values, decreased b* values compared to YC. The b*values did not differ significantly for these samples.

Hue and chroma

The *hue* of any given colour is its closest match within the range of "pure" or "saturated" colours. In terms of physical colour stimulus, this is the range of hues seen in the spectrum (red, orange, yellow, green, cyan, blue, violet), plus the *nonspectral* (purple) hues seen when the two ends of the spectrum are mixed. In terms of colour itself, that is, the mental experience generated by our visual system, it is the range of the four fundamental opponent hues, red, yellow, green and blue, and their respective intermediates. The pH values and Hue and chroma values of mayonnaise samples formulated with varying levels of avocado pulp are shown in Table 2. Hue and chroma values decreased as level of avocado pulp in formulation increased with significantly ($p<0.05$) lower values for 75% and 100% samples.

Carotenoids and Fat content

Carotenoid content ranged between 1.4-1.8μg/g in mayonnaise samples containing avocado pulp. Major proportions of carotenoid came from the olive oil used for preparation which is a potential source of carotenoid. Water activity of the samples was found to be in a range of 0.8-0.9, so that it comes under the category of high moisture food. From the phytochemical analyses, it was found that avocado pulp has considerable amount of nutraceutical potency. The carotenoids content were high in both EY control and avocado mayonnaise samples (fresh) as extra virgin olive oil is also a good source of carotenoids. From the phytochemical analyses, it was found that avocado pulp has considerable amount of nutraceutical potency. Therefore, food application was carried out on mayonnaise, wherein the avocado pulp was added as a source of phytonutrients, as a natural antioxidant and also as a fat replacer. From preliminary trials, it was established that addition of avocado by 15 % by weight of mayonnaise sample resulted in proper combination of it as a fat replacer with reduction in olive oil content required in the blend and as a natural source of antioxidant. The level of oil decreased from. 55% in EY control to 43 % in full avocado sample. The 50:50 sample with maximum acceptability contained only 43% oil. Hence the total fat in this sample was decreased by 12%.

Sensory Analysis

Sensory attributes are categorized into two groups: textural and non- textural sensory attributes. Flavour stability of mayonnaise is also discussed separately.

Textural sensory attributes

Sensory analysis results are shown in Figure 5. Thickness represents viscosity of the sample. 75 % and 100% avocado score of thickness were significantly higher than those of the others as it is clear in Fig. 3 showing viscosity data. Spoonability was defined for panel members as the height of the sample in the spoon and it is related to the thickness of the sample too. No significant differences were found in spoon ability, aftertaste, and overall acceptability of samples containing upto 50% avocado. Indeed panelists did not find the differences between samples due to the high thickness of the samples. In the case of body and creaminess, score of YC and 75 % avocado were lower, may be due to the viscous and thicker texture of YC, made its stirring with spoon a bit difficult because it was not as creamy as the other samples and obtained the lowest score but the differences for this attribute were not significant. All of the samples except 100 % avocado exhibited no fluidity as it was observed when their containers were turned upside down.

Non- textural sensory attributes

Color score of sample YC was the highest one due to the highest amount of yolk. Using 25% avocado affected mayonnaise color significantly but using lower proportions of avocado caused no statistical difference between experimental samples and EC .Score of color of EC was lower than that of 25 % avocado. In the case of taste, EC established the highest score as shown in Figure 6. It may be due to the taste of the egg yolk in combination with egg white affecting the taste of the sample. Using avocado pulp to 50 % did not influence mayonnaise taste considerably and all samples except 75 % and 100% avocado were not significantly different with EC. Analysis of variances showed significant difference only in the appearance characteristic of sensory evaluation of the mayonnaise. Although no significant differences were seen between the control and the 25%, and 50% samples, replacement above 75% resulted in considerable change in colour and flavour of the product. No significant differences were seen in overall acceptability. Total appearance is inclusive of color + texture. The first sensory impression of the quality of a food emulsion is its overall appearance (e.g., its color, opacity, gloss and homogeneity. Substitution at 25 % did not cause significant difference with YC and even the score was higher than EC. The appearance score of sample with 75 % substitution was lower likely because of its color. In support to information reported by McClements (2009), the data of the present study clearly indicate that: the droplet size distribution of an emulsion based food product has a major impact on its physicochemical and sensory properties, e.g., shelf life, appearance, flavor, and texture. Total acceptability is influenced by all attributes. YC obtained the highest score affected by its color and thickness. EC, 25 % and 50 % avocado samples did not show any significant difference in acceptability and as it was expected, the least significant score was related to 100% avocado. Study conducted with avocado at 25, 50 and 75% replacement levels had shown overall acceptability up to the 50% level. This is in keeping with most studies where production of acceptable properties was achieved with partial, instead of total fat replacement. Results showed that yolk-prepared control (YC) had higher stability and viscosity values and the value of these two attributes decreased as more amounts of avocado was used. Color factors changed, which were affected by different proportions of avocado. Sensory evaluation showed no statistical difference in acceptability of YC and samples with substitution levels up to 50 %. So it can be concluded that egg can be substituted with avocado in mayonnaise. As the level of avocado pulp increased in the blend the quantity of oil required for emulsion formation decreased. Similar results have been reported for cookies incorporating avocado puree (Wekwete and Navder, 2008). The product obtained by complete replacement of Egg yolk with avocado pulp was also found to be sensorially acceptable. But a 50% replacement gave a product with maximum overall acceptability. According to total acceptability scores, it can be concluded that using avocado pulp up to 50 % of egg as emulsifier is accepted with a reduction of 12% in olive oil content.

Flavour stability

Mayonnaise traditionally is a mixture of oil, vinegar, egg yolk, sugar, and spices such as mustard, all of which contribute to the overall flavour. Whereas the sugar and vinegar components are relatively stable, there is likely to be significant breakdown of other components such as oil yolk proteins and volatile flavours derived from the spices. Avocado pulp had a very appealing flavour which blended with the other ingredients of the formulation resulting in a better product in terms of flavour. The gentle flavor of avocado was perceived unabated in the mayonnaise prepared using the same. It is thought that most of the initial flavour of the mayonnaise comes from those molecules present in the aqueous phase. As the mayonnaise is diluted by saliva and, to some extent, warmed in the mouth, more of the oil-soluble flavours diffuse out of the droplets and become available to bind to taste receptors. Thus the sensation of a less polar flavour tends to come through after the more polar flavours such as sugar and vinegar, and to become more intense as the fat content of the mayonnaise is reduced and hence more aqueous phase is available (McClements and Demetriades, 1998). In aqueous solution, allyl isothiocyanate from mustard reacts with water and OH ions (Ohta *et al*., 1995) but is stabilized by the addition of citric acid or salad oil (Ina *et al*., 1981), which suggests that it should be stable in mayonnaise. The breakdown of isothiocyanate in mayonnaise is likely to depend on the ratio of oil to aqueous phases, especially as is othiocyanate appears to be stable in oil for extended periods. The breakdown of isothiocyanate appears to be slow even in the aqueous phase under the acid conditions found in standard mayonnaise. The addition of avocado pulp did not cause any adverse change in flavour stability of the product.

Cost benefits

The cost of 1 litre extra virgin oil in India is Rs.1000/-.where as cost of 1kg of avocado varies from Rs.30 to Rs.100. In southern regions of high production, it is available at cheaper rates and hence the reduction of olive oil content in the composition with increasing avocado pulp has got high economical benefits in terms of cost reduction achieved. Approximately Rs100/ Kg cost reduction is achieved by using a formulation containing 20% avocado pulp and 43 % olive oil instead of EY control formulation containing 0% avocado and 55% Olive oil. Commercial preparation may contain 68-70% oil also. Avocados are consumed principally as fresh fruit. However, because of the need to utilize surpluses and imperfect fruits, it has been of interest to process the fruit for extended shelf life time and marketability. Unfortunately, avocado is very sensitive to heating or freezing. The fruit develops off-flavors and discoloration (Golan *et al*., 1977) even after the minimal thermal treatment needed to destroy spoilage microorganisms and deactivate enzymes (Garcia *et al*., 1976). Hence this study is very relevant for achieving a low cost, healthy alternative for mayonnaise with utilisation of avocado pulp.

Conclusion

The low cost avocado mayonnaise developed under this study is an alternative for conventional mayonnaise. This study proves the effect of incorporation of avocado pulp at varying levels in the quality characteristics of mayonnaise. Because overall acceptability was unchanged and the substitutions improved the nutritional content, the results are positive and showed that avocado at 50% EY substitution is capable of producing acceptable substitute for mayonnaise .With the 50% level of EY replacement, the olive oil content for the avocado mayonnaise decreased from 55% to 43%. The avocado mayonnaise had good carotenoid content (1.4-1.8 μg/g mayonnaise) and 12% lower fat content than olive oil-formulated mayonnaise and the market sample. The product obtained with incorporation of avocado pulp had appreciable viscosity, good microstructure, comparable colour. Unlike other low oil preparations, it had good emulsion stability indicated by lower creaming and uniform microstructure. Additional work is highly recommended to test the potential of avocado, a highly nutritious and readily accessible fruit, as a fat replacer in other home made products and also to establish the shelf stability of avocado mayonnaise using different hurdles.

REFERENCES

Aluko RE, McIctosh T. 2005. Limited enzymatic proteolysis increases the level of incorporation of canola proteins into mayonnaise. *Innov Food Sci Emerg Technol.,* 6:195–202.

Drakos A, Kiosseoglou V 2006. Stability of acidic egg white protein emulsions containing xanthan gum. *J Agric Food Chem.,* 54:10164–10169.

Drakos A, Kiosseoglou V 2008. Depletion flocculation effects in egg based model salad dressing emulsions. *Food Hydrocoll.,* 22:218–224.

Garcia, RJ. Andraden and Rolz, C. 1976. Effect of temperature and heating time on the detection of off-flavor in avocado paste. *J Food Sci.* 40: 200.

Ghoush MA, Samhouri M, Al-Holy M, Herald T 2008. Formulation and Fuzzy modelling of emulsion stability and viscosity of gum protein emulsifier in a model mayonnaise system *J Food Eng.,* 84: 348-357.

Goankar G, Koka R, Chen K, Campbell B. 2010. Emulsifying functionality of enzyme –modified milk proteins in o/w and mayonnaise like emulsions *Afr J food Sci.,* 4: 16-25.

Golan AY, Sandovski V and Kahn, 1977. Evaluation of browning potential in avocado mesocarp, *J. Food Sci*., 42: 853-855.

Harrison, LJ and Cunningham FE, 1985. Factors influencing the quality of mayonnaise. Journal of Food Quality, 8: 1–20.

Ina K, Nobukuni M and Sano A and Kishima I. 1981. Studies on the volatile components of wasabi and horse radish. III. Stability of allyl isothiocyanate. *J Japan Soc Food Sci and Technol* 28: 627–631.

Kiosseoglou VD and Sherman P. 1983. Influence of egg yolk lipoproteins on the rheology and stability of oil/water emulsions and mayonnaise 1. Viscoelasticity of ground nut oil in water emulsions and mayonnaise*. J.Texture studies* 14,:397-417.

Maghsoudi SH. 2004. The technology of sauces producing. Marzedanesh, *Tehran*, pp 3–118.

Mangino ME. 1994. Protein interactions in emulsions: protein-lipid interactions. In: Hettiarachchy NS, Ziegler GR (eds) Protein functionality in food systems. M Dekker, New York, pp 147–180.

McClements DJ, 2009. Biopolymers in food emulsions. In: Kasapis S, Norton IT, Ubbink JB (ed) Modern Biopolymer Science, Springer. pp 129–166.

McClements DJ, Demetriades K 1998. An integrated approach to the Development of reduced-fat food emulsions. *Crit Rev Food Sci Nutr.,* 38:511–536

Mine Y. 1998. Emulsifying characterization of hen's egg yolk proteins in oil-in-water emulsions. *Food Hydrocoll* 12:409–415.

Mun S, Kim YL, Kang CG, Park KH. 2009. Development of reducedfat mayonnaise using 4αGTASE modified rice starch and xanthan gum. *Int J Biol Macromol.,* 44:400–407.

No HK, Meyers SP 2004. Preparation of tofu using chitosan as a coagulant for improved shelf life. *Int J Food Sci Technol.,* 39:133–41.

OhtaY, Takatani K and Kawakishi S. 1995. Decomposition rate of allyl isothiocyanate in aqueous solution. *Bioscience Biotechnology and Biochemistry*, 59, 102–103.

Prakash, S Jha, S.K and Datta N 2004. Performance evaluation of blanched carrots dried by three different driers *J.Food Engg*., 62: 305-313.

Rahmati K. Tehrani MM. Daneshvar K. 2012. Soy milk as an emulsifier in mayonnaise: physico-chemical, stability and sensory evaluation. *J Food Sci Tech* 51:3341-3347.

Tung MA and Jones LJ. 1981. Microstructure of mayonnaise and salad dressing. Scanning electron Microscopy, 3: 523-530.

Unlu NZ, Bohn T, Clinton SK and Schwartz SJ.2005. Carotenoid absorption from salad and salsa by humans is enhanced by the addition of avocado or avocado oil. *J Nutr.,* 135:431–6.

Wekwete B and Navder KP 2008. Effects of Avocado Fruit Puree and Oatrim as Fat Replacers on The Physical, Textural And Sensory Properties Of Oatmeal Cookies *J of Food Qual.,* 31: 131–141.

Worrasinchai S, Suphantharika M, Pinjai S, Jamnong P 2006. β- Glucan prepared from spent brewer s yeast as a fat replacer in mayonnaise. *Food Hydrocoll.,* 20:68–78

Yen YH Shiu CH Chang Ch 2008. Effect of adding ascorbic acid and glucose on the antioxidative properties during storage of dired carrot *Food Chem.,* 107:265-272.

****