SOME PHYSIOCHEMICAL AND RHEOLOGICAL PROPERTIES OF PREPARED SPREADABLE TOFU BLENDS

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Some physiochemical and rheological properties of prepared spreadable tofu blend

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Abstract

Recently, the use of soy and soybean products has been grown in food industry. The study objective of the research is to prepare products of spreadable tofu with different flavors. Six formulated spreadable tofu with different flavors were prepared; control without addition, and with chopped green olives, ground black pepper and chopped green peppers; sugar; guava pulp, and peach pulp. The spreadable Tofu blends were subjected to chemical and sensory evaluation to ensure different qualities. L values were decreased with adding fruit, vegetable and spices to tofu. It took 80.16, 79.37, 76.12, 79.28, 75.70 and 75.40 for control, T1, T2, T3, T4 and T5 in respective order. The same trend was observed of A value and B values were increased, while yellowish was decrease because of tofu. Obtained data showed that meltability value in control, T1, T2, T3, T4 and T5 ranged (49-72), (33-55), (42-53), (35-71), (32-70) and (31-70), respectively. The control showed the highest value compared to other treatments. Texture properties of spreadable tofu blend indicated that the ranges of hardness presented (1.2- 8.4N), cohesiveness (0.19-0.63), springiness (2.48-8.00mm), gumminess (0.6-2.6N) and chewiness (3.69-12.66m.j). The highest hardness values was treatment T4 which contain tofu with 20% guava pulp compared to control and other treatments.

Key words: spreadable tofu, texture properties, guava pulp, peach pulp, green peppers, black peppers, green olives.

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Introduction:

Soybeans have been primarily consumed by humans after being fermented and turned into a curd. Tofu, a bland, cheese-like substance made from the whey of fermented soybeans, is the most common example of this kind of soy-product**. Bolla (2015)** assured that soybeans are high in quality protein soybeans contain all the essential amino acids, in adequate amounts needed for health and two- three servings of soy provide ~15-20 g protein.

Tofu appeared to be the most popular among all soy products and also called soy bean curd. It has been made by coagulating hot soymilk with some food grade chemicals such as calcium chloride, magnesium chloride, calcium sulfate, acetic acid and citric acid **(Mchugh, 2016).**

The two most commonly used salt coagulants were calcium sulfate (gypsum) and magnesium chloride combined with calcium chloride (nigari salts) as reported by **Rekha** and **Vijayalakshmi (2013)** and **Kang et al. (2014).**

Vegetables and fruits seemed to be high in fiber and contain many vitamins and minerals as well as hundreds of beneficial plant chemicals (phytochemicals). Diets rich in vegetables and fruit could benefit the heart by lowering blood pressure, cholesterol levels, and inflammation and improving insulin resistance and blood vessel function and weight gain, a lower risk of stroke (**Slavin and Lioyd, 2012 and Willett, et al., 2013).**

Guava, a popular fruit of tropical and subtropical countries, contained 80% moisture 20% dry matter, 1% ash, 0.7% fat and 1.5% protein **(Chauhan, et al., 2014)**. The utility of guava as functional foods have been increasing with the main traditional use preferred as an anti-diarrheas agent for treatment of gastroenteritis, dysentery, stomach, antibacterial colic pathogenic germs of the intestine, other medicinal properties of guava includes treatment of diabetes, hypertension, inflammation etc. **(Metwally, et al., 2010).**

Chauhan, et al. (2014) and Lim, et al. (2011) noted the preference of fresh fruit for consumption but seasonal availability limits consumption

of fruit throughout the year. Hence processed products such as puree, paste, canned slices in syrup or nectar are developed and marketed.

Peaches, considered among the first 3-5 fruit species regarding flavor and complex chemical composition, comprised of 10.0-21.5% dry matter, 5-12% total sugar, 0.4-1.3% protein, 0.2- 0.7% pectin, 0.6-0,86% minerals and vitamins **(Iordănescu and Micu, 2012).**

Peppers, important vegetables, have been used fresh or as a spice (**Marinova, et al. 2005 and Igbokwe et al., 2013).**

Black pepper, one of the most popular spice products in oriental countries, has largely used as a flavoring agent in foods (**Mueller and Hingst, 2013)**. The components of the pepper's extract that contribute to its value as a food additive included the volatile oil for its aroma and the alkaloid compounds for the pungency (**Brewer, 2011**).

Olives as good source of several vitamins and minerals, some of which were added during processing, such as vitamin E, cholin, niacin, vit. A, B6, thiamin calcium, iron, and copper (**Rines and Ardehali, 2013, Abbaspour et al., 2014, Emkey and Emkey, 2012 and Hui, et al. (2015).**

In the last few decades, palm oil's application in food industries has exponentially grown for the texture, the fragrance and the neutral taste it guarantees in the finished products. Its two major fractions consisted ofthe low-melting liquid fraction (known as palm olein, 65%–75%) and the high-melting solid fraction (known as palm stearin, 30%–35%) as reported by **Henson (2012).**

The present investigation aimed to study the effect of mixing tofu with some vegetables and fruits on some physiochemical and rheological properties of spreadable tofu products with different flavors.

Materials and Methods

Materials

a. Soybean seeds (Glycine Max., L., commercial variety) were obtained from Legumes Research Dep., Field Crops Research Institute, Agriculture Research Center, Giza, Egypt.

b. Palm oil from Efico star Co. Egypt

c. Skimmed milk powder from Fonter ALTD; Auckland, New Zealandd. Whey powder from Agropur Granby, Canada.

d. Emulsifying salt (Joha S9 special) from Arabian Food Industries Co. Egypt

e. green olives, ground black pepper ,chopped green peppers, sugar; guava , peach salt (Nacl), from local market.

f. Stabilizers (corn starch, CMC, soluble starch, modified potato starch, Guar gum) from AVEBE U.A. The Netherlands.

g. Q3 {Sodiumcarboxymethyl Cellulose (E 466) - Gur gum (E 412)} stabilizer from BK Giuliani GmbH, Ladenburg, Germany.

Methods

Preparation of Tofu:

- Cooking soymilk in a steam jacketed kettle at 90-95°C for 15-20 min. (Groen, Adover Industries Co., Elk village, USA.
- Weighing 100 kg soymilk in bucket and reheat it at 85°C.
- Adding a warm coagulant powder (0.5 % calcium chloride) to soymilk at 70-80 °C with agitation using a paddle.
- After forming curd allowing it to stand for 15-20min.
- Breaking up the curd evenly and transferring it using a ladle into a forming box lined with moistened cloth, and then covering the box with lid.P
- Pressing with a suitable pressure (at 50 psi for 15-20 min.
- Placing the forming box with tofu in a cooling tank, resetting to the tofu for 5 min, unfolding the cloth and removing the tofu.
- Cutting the tofu into pieces (about 3×4 × 5 cm.
- Packing & Immersing tofu in plastic bags without any addition in chilled water **(Benassi et al., 2011**) and **(Agrahar, 2014).**

Preparation of Spreadable tofu with some commodities

The suitable amounts of raw materials (soy curd (Tofu), Skimmed milk powder, whey proteins, palm oil, Stabilizers {(Q_3) Sodium carboxymethyl Cellulose + Guar gum}, emulsifying salts and water were used for preparing spreadable tofu blends. The raw materials with added commodities and water were added consecutively in laboratory processing Kettle (Thermomix TM 31 made in Australia Pty Ltd 2010) as mentioned by **Awad (2014**). All blends were adjusted to contain 58% moisture, 50% fat/DM and 2.5% emulsifying salts (Joha S9 special). Some vegetable, fruits and spice were added to the formula as a substitute of tofu. The mixture was cooked for 10 min at 85-90°C using indirect steam at pressure 2-2.5 kg/cm2. The mixture was hot filled into wide mouth glass jars and capped directly after filling. The resultant spreadable tofu was analyzed when manufactured and after 1, 2 and 3 months of storage in refrigerator (5 ±2°C).The mixture was cooked for 10 min at 85-90°C using indirect steam at pressure 2-2.5 kg/cm2 then was hot filled into wide mouth glass jars and capped directly after filling. The spreadable tofu samples were analyzed at 0, 1, 2 and 3 months of storage in refrigerator (5 ±2°C).

Formulations of all the six tofu blends consisted of skim milk powder (50g), whey powder (30g), and emulsifying salts (25g). The other remaining commodities per 1000 g were different in the six prepared blends as follows:

Control (C): 454.75soy curd, 172.03Palm oil, 30Q_3, 238.22 g water.

T1: 404.75soy curd, 170Palm oil, 35Q_3, 50chopped green olives and 235.25 g water.

T2: 427.75soy curd, 176.45Palm oil, 38Q_3, 0.2 % ground black pepper and 2.5% chopped green peppers and 235.25 water g.

T3: 434.75soy curd, 174Palm oil, 30Q_3, 20 sugar and 236.35 g water.

T4: 404.75soy curd, 170Palm oil, 35Q_3, 200Guava pulp and 77.69 g water.

T5: 404.75soy curd, 170 Palm oil, 35 Q3, 150 Peach pulp and 63.52 g water.

Physicochemical properties:

- ***Determination of meltability property***

The meltability of blends was represented by the difference (Dt) between sample area at cooking time t (min) and that before cooking: Dt = At - A0; where At is the sample area (mm^2) in t min cooking and A0 is the initial sample area (mm^2). Meltability of spreadable tofu blend was tested as described by **Wang and Sun (2002).**

- ***Color measurement***

Surface color of spreadable tofu with some additives samples were determined according to the tristimulus color system described by **Francis (2000)** using spectrophotometer (MOM, 100D, and Hungary). **Color** coordinates X, Y&Z were converted to corresponding hunter L*, a*& b*, from where

Hue (hє = arc tan b/a), chroma [C* = (a2 + b2) 1/2], intensity = (a2 +b2 +L2)1 /2

Color coordinates according to formula given by manufacturer.

- L: value represents darkness from black (0) to white (10))
- A: value represents color ranging from red (+) to green (-)
- B: value represents yellow (+) to blue (-)
- C: Chroma
- Hue (hє): tone angle or color
- Intensity: chromaticity of color saturation

The determinations were performed in triplicate, with the calibrated equipment, using 3 samples from each formulation indicated by **Pathare, et al. (2012).**

Rheological properties

- ***Texture profile analysis (TPA)***

Texture profile analysis test of samples was done using a Universal Testing Machine (TMS-Pro) Food Technology Corporation, Sterling, Verginia, USA) equipped with 1000 N (250 lbf) load cell and connected to a

computer programmed with Texture Pro^{TM} texture analysis software (program, DEV TPA With holding time between cycle two second). A flat rod probe (49.95 mm in diameter) was used to uniaxially compress the samples with the following parameters conduction to 30 % of their original height. The texture profile analysis test set condition was adjusted to a test speed 50 mm/sec; trigger force 1N, deformation 40% and holding 2 sec between cycles). Each sample was subjected to two subsequent cycles (bites) of compression-decompression. Calculation described by **Szczesniak et al (1963) and Bourne (1978)** was used to obtain the following texture profile parameters (Hardness, Cohesiveness, Springiness, Gumminess and Chewiness)

RESULTS AND DISCUSSION

- ***The preliminary Experiment***

Soybean product

In order to select, a product from soybean products as a base material for the present study, the experiment was conducted:

Suitable emulsifying salts and stabilizers

Different types of emulsifiers and emulsifiers were tested:

Q_3 (3 %) and special S_9 (2.5%) were selected as emulsifying salts as the product had a good texture similar to cheese made from the natural milk.

Appropriate flavors

a. Artificial flavorings materials: Three materials were tested for flavor, i.e. Cheddar cheese, black peppers and green olives. Good results have given a high degree of sophistication in sensory judgment.

b. Natural nectars: Natural nectars of fruits, vegetables and spices were used.

Fruits (orange pulp - peach - guava - mango - strawberry -black berries - pomegranate- red plum) with different proportions.

Vegetables (chopped green peppers, chopped pickled green olives, chopped black olives, dried tomatoes and ground dried carrots with different proportions.

Spices: different ratios of Black pepper with green peppers.

Based on the sensory judging, 15% peach pulp and 20% guava pulp were selected.

5 % chopped green olives and a mixture of 0.2% ground black pepper with 2.5% chopped green peppers was selected.

Fat kind

Different materials were tested: cocoa substitute butter - coconut oil - olive oil – Palm oil and shortening). Palm oil gave an excellent product that did not affect the flavor of the final product.

• ***Instrumental analysis of color.***

From data in table (1), it could be seen that L value (which the whiteness of sample) was decreased with adding fruit, vegetable and spices to tofu. It took 80.16, 79.37, 76.12, 79.28, 75.70 and 75.40 for control, T1, T2, T3, T4 and T5 in respective order. The same trend was observed of A value (which reflect the blue and red color) and B value (which reflect the yellowish color).

It could be concluded that whiteness of sample was increased while yellowish was decrease because of tofu, this results agree with **Agrahar (2014)** who found that L values from 78.8 to 87 and B values from 13.4 to 18.8, and would easily gain acceptance in populations who consumed these products.

Table (1): Color characteristics of spreadable tofu products in fresh

Parameters	Values in spreadable tofu blends					
	C	T1	T2	T3	T4	T5
L	80.16	79.37	76.12	79.28	75.70	75.40
A	- 6.4	- 7.49	- 6.7	- 6.98	- 6.57	- 5.7
B	17.44	18.24	18.08	18.29	20.13	18.95
H*	69.8	82.2	69.67	69.11	71.91	73.26
C*	18.58	19.72	18.94	19.57	21.17	20.11
Intensity	82.29	81.79	78.53	81.65	78.60	77.96

C: spreadable tofu without any flavor, T1: spreadable tofu with Chopped green olives, T2: spreadable tofu with Mix ground black pepper

and chopped green peppers, T3: spreadable tofu with sugar; T4: spreadable tofu with guava pulp, T5: spreadable tofu with peach pulp, C*: Chroma, H*: Hue (hє), tone angle or color

Similar observation was noticed by **Jayasena, et al. (2010)** reported that A white, creamy white or light yellow color would be considered as a desirable tofu characteristic that ascribed to ingredients kinds in control and treatments.

- ***Texture profile analysis***

Table (2) illustrated texture properties of spreadable tofu blend. Data indicated as hardness ranged (1.2- 8.4N), cohesiveness (0.19-0.63), springiness (2.48-8.00mm), gumminess (0.6-2.6N) and chewiness (3.69-12.66 m.j). The highest hardness values was treatment T4 which contain tofu with 20% guava pulp compared to control and other treatments.

Table 2. Textural profile analysis (TPA) of spreadable tofu products.

Parameters	Storage period (month)	Ratio of tofu%				
		C	T1	T2	T3	T4
Hardness (N)	Fresh	2.7	2.1	3.9	6.4	6.8
	1	2.6	2	3.1	4	4.2
	2	2.5	1.9	2.9	3.8	3.7
	3	2.5	1.9	2.9	2.7	2.4
Cohesiveness(Ratio)	Fresh	0.63	0.59	0.38	0.45	0.6
	1	0.57	0.42	0.33	0.45	0.26
	2	0.55	0.4	0.28	0.44	0.26
	3	0.54	0.38	0.19	0.43	0.26
Springiness (mm)	Fresh	2.48	3.5	5.95	4.39	5.38
	1	4.53	6.04	6.02	5.69	5.43
	2	5.97	7.98	7.97	5.7	6.33
	3	7.97	8	8	7.96	7.93
Gumminess (N)	Fresh	1.7	1.1	1.3	1.9	1.8
	1	1.48	0.9	1	1.7	1.5
	2	1.4	0.8	0.8	1.5	1.4
	3	1.38	0.7	0.6	1.2	1.1
Chewiness (m.j)	Fresh	11	6.95	10.13	12.66	11.35
	1	10.89	6.85	8.90	9.68	9.64
	2	6.54	6.19	7.24	6.58	6.44
	3	4.17	6.19	3.69	4.62	4.52

C: spreadable tofu without any flavor, T1: spreadable tofu with Chopped green olives, T2: spreadable tofu with Mix ground black pepper and chopped green peppers, T3: spreadable tofu with sugar; T4: spreadable tofu with guava pulp, T5: spreadable tofu with peach pulp.

Cohesiveness, gumminess and chewiness was positively related to the hardness of treatments compared to springiness took the opposite line with the hardness. These findings agree with those of **Gholamhosseinpour et al. (2018).**

- ***Meltability***

Obtained data in Table (3) showed that meltability value in control, T1, T2, T3, T4 and T5 ranged (49-72), (33-55), (42-53), (35-71), (32-70) and (31-70), respectively. Nevertheless, the control showed the highest value compared to other treatments.

Table 3. Change in meltability (mm) of spreadable tofu products.

Storage period (month)	Spreadable tofu blends					
	C	T1	T2	T3	T4	T5
Fresh	72	55	53	71	70	70
1	68.8	44.1	52	66	54	50.5
2	56.1	46	47	53.5	51	47
3	49	33	41	35	32	31

C: spreadable tofu without any flavor, T1: spreadable tofu with Chopped green olives, T2: spreadable tofu with Mix ground black pepper and chopped green peppers, T3: spreadable tofu with sugar; T4: spreadable tofu with guava pulp, T5: spreadable tofu with peach pulp.

These results in harmony with **Farahmandfar et al (2010, 2011)** pproved that the decrease in stretch ability could be due to less percentage of casein available for conversion to mono-calcium-paracaseinate by the addition of soy solids, also the spreads became less rubbery, lack elasticity, impaired flow and stretchability with increasing substitution of plant protein e. g., soy protein.

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بعض الخصائص الفيزيوكيميائية والريولوجية لخلطات التوفو القابلة للفرد

الملخص العربي

إن دراسة استخدام فول الصويا كعنصر غذائي مؤخرا في صناعة الأغذية و استهدف البحث إعداد منتجات وظيفية من التوفو .تم إعداد ستة خلطات من التوفوالقابله للفرد مع نكهات مختلفة . العينه الضابطه توفو دون إضافات ,ومع الزيتون الأخضر المفروم والفلفل الأسود المطحون والفلفل الأخضر المفروم؛ السكر؛ لب الجوافة، ولب الخوخ .خضعت خلطات التوفو القابلة للتوزيع للتقييم الفيزيوكيمياوى والريولوجى لضمان صفات الجوده المختلفة .لوحظ انخفاض قيم L*بإضافة الفواكه والخضراوات والتوابل إلى التوفو .بالنسبة للون سجلت 80.16 و 79.37و 76.12و 79.28و 75.70و 75.40 لمقارنة و T1و T2و T3و T4و T5على التوالي .لوحظ نفس الاتجاه للقيمة A* والقيمة B*، وتراوحت درجات القابليه للأنصهار T1، T2، T3، T4, T5 (49–72)، (33–55)، (42–53)، (35–71)، (31–70) (32–70)على الترتيب أعلى قيمة مقارنة بالمعاملات الأخرى .كما أشار نموذج تحليل التركيب البنائى لمزيج التوفو القابل للتوزيع إلى أن الصلابة تراوحت بين 1.2و N 8.4، وقوة التماسك (0.19–0.63)، والمرونة –2.48) (8.00mmوالصمغيه (0.6–2.6N)، و المضغيه (.(3.69–12.66m.j)تفوق عينات التوفو القابل للفرد ذات النكهات الطبيعية المختلفة مقارنة بالعينه الضابطه.

الكلمات الدالة :التوفو القابل للفرد , لب الجوافة ، لب الخوخ ، الفلفل الأخضر ، الفلفل الأسود ، الزيتون الأخضر اللون ,صفات التركيب البنائى