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Management

DEVELOPMENT OF HEALTHY DATE BREAD

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ABSTRACT

This research aims to study the development and the consumer acceptance of healthy date palm based whole wheat bread. Initially, the optimized raisin bread recipe was selected by 5 experts in food and that was used as a basic recipe for date fruit fortification. The raisin content in the bread recipe was replaced with a date palm. In order to increase the nutritional value of the bread, multi-purpose flour in the basic bread recipe was substituted with whole wheat flour at the ratio of 50% and 100% and the level of sugar in the basic bread recipe was reduced to 0%, 75% less sugar and 50% less sugar when compared with the basic recipe. Preference ranking test of the six recipes were conducted by using 30 panelists. A consumer acceptance test of the selected date palm bread was conducted with 50 target consumers. The statistics, percentage, mean and standard deviation of the test were analyzed.

Results from the selection of basic recipe by 5 food experts found that the best bread recipe included 32.2% of bread flour, 24.1% of water, 20.1% of raisins, 8% of multi-purpose flour, 4.8% of sugar, 4% of eggs, 0.8% of sweet yeast, 0.6% of salt and 0.4% of KS505. The ranking result showed that the preference ranking between the six recipes were not significantly different at the 95% confidence level. The most preferred recipe was with 100% wheat flour substitution and 75% reduction of sugar (32.2% of bread flour, 24.1% of clean water, 20.1% of date palm, 8% of whole wheat flour, 4% of eggs, 1.2% of sugar, 0.8% of sweet yeast, 0.6% of salt and 0.4% of KS505). The consumer test found that 98% of consumers accepted the product and 64% decided to buy the product.

Keywords: Bread, Date palm, Whole wheat, Ranking, Consumer acceptance.

Introduction

Bread is a basic foodstuff widely consumed as part of daily diet. It is an important source of dietary energy for millions of people worldwide. Accordingly, the nutritional impact of bread consumption to the health of population is quite high. However, nutritional value of white bread is mainly composed of carbohydrate and very low in protein, vitamins and minerals. Therefore, it is necessary to improve the nutritional quality of bread for maintaining health of population.

Bread have been fortification with many natural nutritious ingredients. For example, pumpkin seed was used for protein fortification in bread. Raw pumpkin seed can add up to 17% of protein level in bread (El-Soukkary, 2001). Peng et al. (2010) used grape seed extract to enhance antioxidant level in bread. Fendri et al. (2016) enriched the bread with pea and broad bean pods fibers to improve nutritional value of the bread and made product suitable for diabetics. Nithya et al. (2020) incorporated pullulan as a prebiotics in bread to enhance the functional and nutritional value.

Date palm or In-tha-pha-lam in Thai language, is an inexpensive source of sugar, minerals (selenium, potassium, calcium, magnesium, manganese, iron) dietary fiber, carotenoids, fatty acids and vitamins. Date fruit helps the body to quickly refresh and restore energy. A 100 grams of date palm provide approximately 282 kilocalories of energy, 75.03 g of carbohydrates (63.35 g of sugar),

2.45 g of protein, and 0.39 g of fat (Belewu et al., 2014). Moreover, it contains many antioxidants such as polyphenols, anthocyanin, and β-glucan that act as a strong anti-diabetic, anti-inflammatory and anti-tumor (Hussain et al., 2019). Consequently, date fruit can be a highly potential healthy ingredient for bread fortification.

In order to improve the health benefits of date palm bread, whole wheat flour was used due to high fiber, vitamins and mineral content. Additionally, use of whole wheat flour in the formulation of date based bread contributes towards nutritional product with low glycemic index (GI). This research aims to develop less sugar date palm based healthy bread recipe and evaluation of consumer acceptance of the developed bread.

Objectives

1. To develop less sugar date palm based whole wheat nutritional bread
2. To study the consumer's acceptance toward the healthy date based whole wheat bread.

Literature Review

1. Basic ingredients of bread

Bread is a leavened baking product. The production of bread includes 2 stages which are dough fermentation stage and baking stage. Bread traditionally composes of wheat flour as a major ingredient, the other ingredients of bread are water, yeast, sugar, salt and fat. The role of each ingredient is described as following

1.1 Wheat flour

Wheat flour is an important ingredient in bread making. Commercially, bread is made with white wheat flour. The major constituent of wheat flour are starch and proteins. Starch plays an important role in bread structure. During dough mixing, starch absorbs water and sugar is liberated from starch by enzyme. During baking of bread, the starch granules are generally gelatinized and destroyed. This forms a continuous network of starch and after cooling, the gelatinized starch is retrograded or becomes staling (Gray and Bemiller, 2003).Wheat proteins are classified into albumins, globulins, gliadins and glutenins. Gliadins and glutenins are gluten proteins. Both of them are a major structure-forming protein present in wheat flour (80 - 85% of total wheat protein). They have ability to form a viscoelastic mass call gluten which is able to retain gas bubble during fermentation. The amount of gluten protein affects the bread volume and crumb structure (Wieser, 2000).

1.2 Water

The amount of water in dough mixing resulted in the bread texture after baking. Approximately 50% water resulted in a finely light texture of the bread while the higher water percentages resulted in more CO_2 bubbles, and a coarser bread crumb (Gray and Bemiller, 2003).

1.3 Yeast

Yeast is a tiny, single cell that act as a leavening agent in the dough mixing stage. The general type of baker's yeast is *Saccharomyces cerevisiae*. When the instant dried yeast is used, the preconditions required for growth are humid and warm (25-30 °C) condition. During the fermentation, yeast breaks down starch molecules into simple sugars, which is converted into ethanol and CO_2, the air bubbles that rise the bread dough to expand (Ali et al., 2014)

1.4 Sugar

Sugar is added for initiation of fermentation. As a sugar content increase, the air bubble from fermentation increase. Moreover, sugar provide a soft and tender texture of the bread by absorbing the water and slowing down the formation of gluten strands. This leads to the high loft volume and soft texture of the bead. However too high-sugar concentration (more than 30 % sucrose

per weight of flour) cause harsh osmotic stress that badly damages cellular mechanism of yeast and resulted in the decreases of dough aeration. (Verstrepen et al., 2004; Trinh et al., 2015)

1.5 Salt

Salt is added to strengthen the gluten and control the yeast fermentation rate that related to the expansion of the dough. Gas formation of the dough has decrease with high salt concentration (Luchian and Canja, 2010)

1.6 Fat

Fat is used as an air bubble stabilizer. When the fat interacts with the gluten protein in the dough, it form lipid monolayers at the gas/liquid interphase of the gas cells, thus increasing the gas retention of the dough. This leads to the improvement of loaf volume and finer texture of bread (Gan and Schofield, 1995)

2. Whole wheat bread

Generally, white bread is made with white flour. The white flour is made from only endosperm of the wheat. The bran and the germ of the wheat are removed during the milling process in order to improve white flour's shelf life. Accordingly, some nutrients such as dietary fiber, iron, B vitamins micronutrients and essential fatty acids are discarded.

(a) Whole wheat　　　　　　　　　　　(b) Refine wheat

Picture 1: Structure of wheat grain before milling into (a) whole wheat flour and
(b) white wheat flour

In contrast, whole wheat flour is made from the entire grain, including the bran, endosperm, and germ as showed in **Picture 1**. The nutrition compositions of white wheat flour and whole wheat flour are showed in Table 1. Whole wheat flour has more fiber and minerals than white wheat flour. Accordingly, white bread is considered a high glycemic index (GI) food since it can easily digest and increase blood glucose when compare with whole wheat bread that have move fiber content which is hard to digest.

Table 1: The nutrition compositions of white wheat flour and whole wheat flour

Component	White wheat flour	Whole wheat flour
Starch (%)	62.20	52.20
Protein (%)	15.40	15.50
Fat (%)	6.21	7.31
Fibre (%)	2.01	9.25
Calcium (%)	0.31	0.35
Phosphorus (%)	0.16	0.37
Magnesium (%)	0.03	0.11
Iron (%)	1.60	2.91
Zinc (%)	1.63	2.93

Source: Reeves et al. 1993

3. Date palm

Date palm also known as the Western Dates (*Phoenix dactylifera* L.) is a fruit tree that grows well in hot and arid areas like in the Middle Eastern countries. The fruits are both small and large, forming a juicy sweet taste that can be eaten both raw and ripe. The dried ripe fruit is sweeter than the raw one and can be stored for many years.

Date palm provides flash energy due to its high sugar content. Also, it has dietary fiber, many vitamins and minerals, especially potassium (696 mg./100 g.), which helps the body to quickly refresh and restore energy (Ghnimi et al., 2017).

There are lot of pharmacological studies on date palm. Most in-vitro studies found that the date palm has antioxidants, anti-inflammatory, fat and blood sugar reduction activities and helps to protect the liver, kidneys, and the death of heart cells. It also contains anti-mutagenic, anti-microbial, hepato-protective, anti-cancer, and immune-stimulatory activities (Khalid et al., 2017). For clinical studies, it was found that the triglyceride levels of healthy volunteers given a dose of 100 g / day of dates for 4 weeks were decreased. It also helps prevent arteriosclerosis. No adverse effect on blood sugar levels was found. Moreover, the studies in men with erectile dysfunction found that date palm pollen (DPP), which is rich in amino acids, fatty acids, flavonoids, saponins and estroles, can help increase sperm number and motility speed as well as increasing testosterone levels. Furthermore, the DPP also helps prevent inflammation from cancer treatment by radiation, as well.

It can be seen that the date palm is a high nutritional fruit that has a wide range of pharmacological effects. Therefore, eating 5 to 10 dates per day instead of consuming soft drinks or snacks containing only flour, fat and sugar is more beneficial and healthier. However, since date palm has high potassium, people with health problems or disabilities to eliminate potassium from the body, such as patients with chronic kidney failure, diabetes and heart failure must be extra careful when consuming to prevent excess potassium (Hyperkalemia), which may be harmful to the body (Krittiya, 2016).

Methods

1. Development of less sugar date palm bread

Initially, the best raisin bread recipe was selected by 5 experts in food from Faculty of Food Business Management, Panyapiwat Institute of Management. The selected bread recipe was used as a control (Table 2). The amount of raisin in the selected bread recipe was replaced with a date palm in order to increase a nutritional value of the bread. Multi-purpose flour in the basic bread recipe was substituted with whole wheat flour at the ratio of 50% and 100% and the level of sugar in the control was reduced to the ratio of 0%, 25% and 50%. All ingredients were mixed with the mixer. The dough was kneaded and left to rise for 30 min. After that it was shaped, put into the tin and proved followed by baking at 160°C for 30 min. Preference ranking test of the date palm bread recipes were conducted by using 50 panelists. The samples were randomly served by using the order from the table of permutation 1-9 (for 7 samples). Each sample was single-serve every 2 minutes. The differences between rank sum were calculated and compared with the critical values of differences between rank sum at $\alpha = 0.05$ (N=50, Sample =7) as method described by Christensen et al. (2006).

Table 2: Ingredients list of the date palm bread with different level of whole wheat flour and sugar.

Ingredients (g/100g)	Control	50% whole wheat replacement			100% whole wheat replacement		
		No Sugar	75% less Sugar	50% less Sugar	No Sugar	75% less Sugar	50% less Sugar
		T1	T2	T3	T4	T5	T6
Bread flour	32.2	32.2	32.2	32.2	32.2	32.2	32.2
All-purpose flour	8.0	4.0	4.0	4.0	0	0	0
Whole wheat flour	0	4.0	4.0	4.0	8.0	8.0	8.0
Sugar	4.8	0	1.2	2.4	0	1.2	2.4
Yeast	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Salt	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Bread Improver (KS505)	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Eggs	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Water	24.1	24.1	24.1	24.1	24.1	24.1	24.1
Date palm	20.1	20.1	20.1	20.1	20.1	20.1	20.1

2. Consumer acceptance test

A consumer acceptance test of the selected date palm bread was conducted with 50 target consumers. Consumers were asked to evaluate the bread color, leaven volume, date palm aroma, date palm flavor, sweetness, taste, chewiness, softness and overall liking of the bread sample on a 9-point hedonic scale   (1 = "dislike extremely," 9="like extremely"). The statistics, percentage, mean and standard deviation of the test were analyzed.

Results and Discussion

1. Development of date palm bread

Results from the selection of the basic recipes by all 5 food experts found that the best recipes were 32.2% of bread flour, 24.1% of water, 20.1% of raisins, 8% of multi-purpose flour, 4.8% of sugar, 4% of eggs, 0.8% of sweet yeast, 0.6% of salt and 0.4% of KS505. The raisin in the selected formula was substituted by date palm. In order to improve the healthy date bread, the sugar was reduced to 0%, 25% and 50% of the basic recipe and the wheat flour was replaced by whole wheat flour at level of 50% and 100%. The randomized complete block design (RCBD) was used to design the treatments into 7 treatments according to Table 2 (include control). Rank sum differences (Max – Min) was 63 which lower than the critical rank sum (n=64) from Table described by Christensen et al. (2006). The result from preference ranking test show that consumer preference towards all of the six treatments were not significantly different at level of 0.05. However, the rank sum of T5 which are 100% whole wheat flour replacer with 75% less sugar was highest, accordingly, it was chosen for further sensory evaluation.

Table 3: The different of rank sum of date palm breads sample Control, T1, T2, T3, T4, T5 and T6

| Samples	Control	T1	T2	T3	T4	T5	T6
Rank sum	177	178	214	196	192	240	203

The comparison of nutritional value between the control date bread and the improved date bread (T5; 100% whole wheat replacement with 75% less sugar indicated that the improved bread has lower calories (220.2 kcal) and carbohydrate (49.5 g). Moreover, it contained higher dietary fiber, zinc, iron, magnesium and calcium. Accordingly, the improved date bread is healthier than the original recipe in term of low carbohydrate.

Table 4: The comparison of nutrition between control and selected date palm bread

Nutrient	White bread with raisin	75% less sugar whole wheat with date palm
Energy (kcal.)	224.9	220.2
Water (g.)	36.0	36.3
Protein (g.)	2.4	2.5
Fat (g.)	0.8	0.9
Carbohydrate (g.)	50.4	49.5
Dietary fiber (g.)	2.0	3.2
Cholesterol (µg.)	15.8	15.8
Vit. A (mg.)	15.3	15.7
Sodium (mg.)	244.4	241.3
Zinc (mg.)	0.5	0.7
Iron (mg.)	0.6	1.0
Potassium (mg.)	181.8	175.4
Phosphorus (mg.)	61.1	72.9
Magnesium (mg.)	9.6	25.2
Calcium (mg.)	15.3	23.7

2. Consumer acceptance on date palm bread

Date palm bread prepared by replacing wheat flour with whole wheat flour at the level of 100% (w/w) and reducing sugar to level of 75% less sugar was found to be more acceptable from sensory point of view. Accordingly, its sensory attributes including the bread color, leaven volume, Date palm aroma, Date palm flavor, sweetness, taste, chewiness, softness and overall liking of the bread were evaluated by 50 panelists. Over 80% of the panelists slightly like the softness, chewiness, sweetness, the date palm flavor, aroma and the bread color while moderately like the taste, leaven volume and overall acceptance of the developed bread as showed in Picture 2. Over 98% of consumer accepted this product and 64% of them decided to buy the date palm bread.
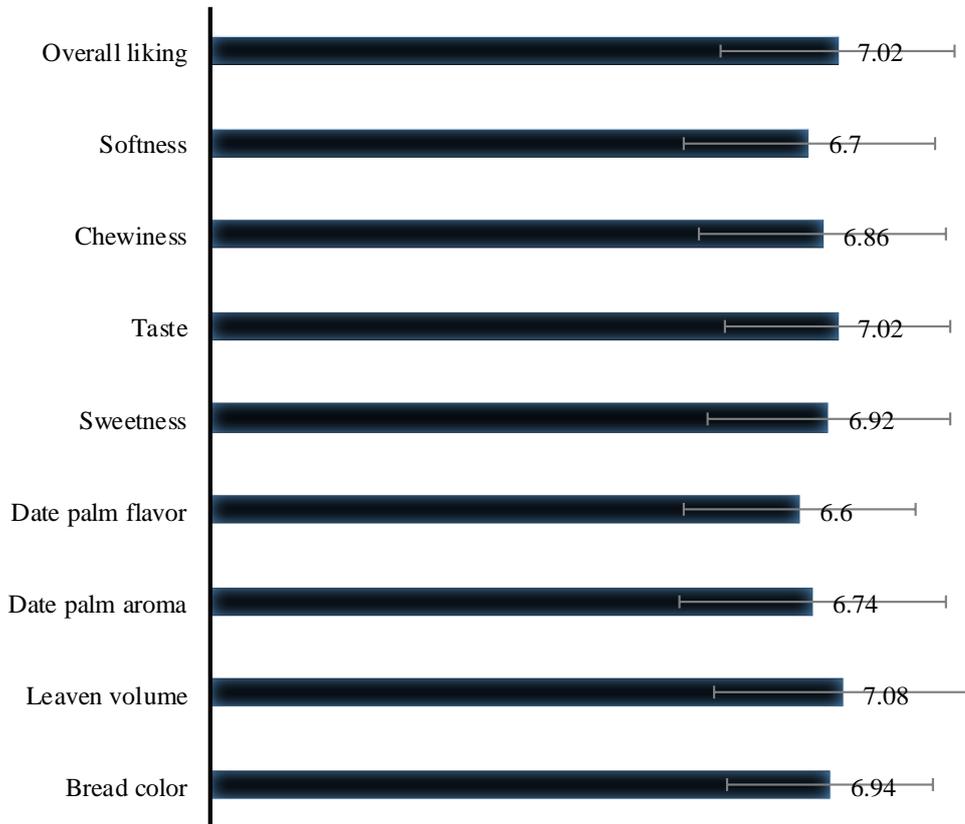
Picture 2: The sensory score of the developed date palm bread.

Conclusions

The developed healthy date palm bread recipes contained 32.2% of bread flour, 24.1% of clean water, 20.1% of date palm, 8% of whole wheat flour, 4% of eggs, 1.2% of sugar, 0.8% of sweet yeast, 0.6% of salt and 0.4% of KS505. The substitution of date palm and whole wheat into the bread led to improve in nutrition values and the overall liking attributes. The consumer moderately like the overall attributes of this product. Over 98% of consumer accepted this product and 64% of them decided to buy the date palm bread for 30 THB per 130 g.

Acknowledgements

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THE IMPACTS OF INTELLECTUAL PROPERTY ON BUSINESS PERFORMANCE: AN EVIDENCE OF THE OPTOELECTRONIC INDUSTRY IN TAIWAN

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ABSTRACT

The research is carried out to develop a sound knowledge on the impact of intellectual capital on company's business performance. The purpose of this study is to investigate the basic four elements of intellectual capital, such as customer, human, innovation, as well as process capital. This study is conducted with the help of the partial least squares (PLS) method by taking Smart plus. The data here is collected from 121 listed companies from stock exchange market and over-the-counter market in the optoelectronic industry during the period 2014-2018 in Taiwan. Results show that intellectual capital elements directly affect business performance, with the exception of human capital. There also exists a relationship among four elements of intellectual capital. Human capital affects innovation capital and process capital. Innovation capital affects process capital, which in turn influences customer capital. Finally, customer capital contributes to performance. The model proposed in this study is applicable to the optoelectronic industry. Modification of the proposed model may be needed in applying this model to other industries. This study helps management identify relevant intellectual capital elements and their indicators to enhance business performance.

Keywords: Intellectual capital, Business Performance, Taiwan, Optoelectronic Industry

Introduction

Taiwan Optoelectronic Semiconductor Industry Association (TOSIA) mainly aims for agglomerate domestic consensus on the development of the optoelectronic semiconductor industry, in terms of promoting collaboration that is strategic among their members, as well as advancing and bring prosperity to the industry. On the other hand, it also tends to provides efforts with different main associations and industrial firms, and the Industrial Technology Research Institute to develop an industrial development platform in terms of providing effective technical along with the professional services and boosting the overall competitive advantages with regards to the optoelectronic semiconductor industry in Taiwan.

In the context of any business environment, it can be said that intellectual capital is the most critical factor that helps a company in developing and achieving competitive advantages. Intellectual capital tends to be intangible in nature, and hence there are many challenges that a company face at the time of determining the value (Abhayawansa et al. 2019). By taking the help of intellectual capital, it becomes easier for companies to create wealth and produce high valued assets. It thus includes the wealth of ideas and the ability to innovate that will help in earning brand value for the firms. Intellectual property mainly has three elements, such as human capital, relational capital, as well as structural capital. Human capital is the collection of skills and creativities of the workers, which mainly increase with the help of training programs. Structural capital is the component of intellectual capital. On the other hand, relational one is responsible for maintaining relationship with

the external stakeholders. Hence, these are essential for enhancing the performance of the company. Thus, from many kinds of research, it is quite evident that intellectual capital has impacted the business organizations in many ways. By taking the help of this, it is now possible for them to enhance competitive advantage, facilitating innovation, increasing the performance of the organization and enhance the competency of the employees engaged in the firms (Ahmed et al. 2019).

Objectives

This particular study is investigating the relationship between the elements of business performance as well as intellectual capital. Not only intellectual capital but the study will also shift its focus on the intellectual capital's other components, such as: innovation capital, human capital, consumer capital, process capital. And how they tend to influence the business performance of the organizations in the optoelectronic industry (Dženopoljac et al 2016).

The main objectives of this study:

- To investigate the elements of the intellectual capital and its impact on the performance of the business
- To analyze the relationship among the components of the intellectual capital

Literature review

Intellectual capital

It can be said that moving towards knowledge-based societies is one of the most significant issues that is discussed at present to a great extent. Firms are not an exception, and they have experienced high amount of change. The concept of the competitive advantage is mainly established using organizational ideas, enterprise knowledge, intellectual capital as well as new economic ideas. In recent times, intellectual capital is mainly equated with knowledge assets. Furthermore, intellectual capital also consists of the intangible assets that are not reported by the business financial statements. However, there are more than 80% of the Taiwanese companies whose market value tends to depend on intellectual capital. Author states that intellectual capital is mainly the collection of the information, knowledge, experience, and intellectual property rights of each and every individual in a business entity. Broader intellectual capital delimitation states that it is mainly the difference between a firm's book value and market value for its financial advantages (Kianto et al. 2017). When contrasting to an organization's tangible resources, the investments related to the intellectual capital, along with their efficiency, cannot be reported and determined in the financial statements. Hence, by measuring the intellectual capital, it can be regarded as conceptualization that answers the needs of the manager for having an operative notion of the intangible and cognitive resources of the company. On the other hand, it also tends to highlight a critical knowledge factor for supporting and improving the continuous performance enhancement in a company as much as possible (Muda& Rahman, 2019).

Impact of intellectual capital on firm performance

A study by some scholars highlighted the fact that intellectual capital is one of the most useful tools that is used for promoting the effectiveness of a company. Intellectual capital is also that element that makes sure of an organization's survival. Intellectual assets that have been formalized captured, as well as even leveraged. Furthermore, the intellectual materials tend to help for creating wealth as well as they also help to produce the high valued assets. Intellectual capital is mainly the knowledge, skills, experience, as well as consumer relationships that offer a company with competitive advantages over its potential competitors (Zahedi et al. 2019). In the new economy, intellectual capital

is one of the main prominent resources for generating growth and wealth. It is also one of the strong firm enhancers of the performance and booster of the market value. Intellectual capital via experience, knowledge management, information, and intellectual property can be used for creating wealth; hence it has been one of the most important elements for the performance of a company. The managers of an organization, as argued by some of the scholars, need to pay the required attention towards the intellectual capital management of the company mainly by aiming to identify its most vital components for the performance of an organization.

Intellectual capital can also bring forth the best performance of the business both in the quantitative as well as qualitative terms. In terms of the quantitative, intellectual capital tends to contribute a huge amount of profitability, return on investments, and assets. Furthermore, another quantitative aspect in the business that enhances because the intellectual capital includes the retention rate of the consumers as well as the market share. The quantitative aspects also consist of consumer satisfaction and loyalty and employee satisfaction. As per some of the scholars, it has been stated that intellectual capital tends to bring innovation that results in competitive advantages, which tends to enhance a firm's performance. Intellectual capital is hence related to the performance of the business in a positive manner (Sharabati et al. 2016).

Human capital mainly includes the experience, knowledge as well as the special skills of personnel of a business entity employed for creating the economic value. Furthermore, the assets and resources tend to define the value of an organization related to the people of a company. Human capital is such a factor that contributed a lots to the performance of the business. The aspects of human capital competency, as well as creativity, emerged as one of the main factors that influences the performance of the business (Petersen &Svensson, 2016).

Relational capital consists of the relationships with the government and the consumers and refers to the maintenance and the development of the vital relationships, for instance, those with the suppliers and consumers of the services and the goods, along with the degree consumer loyalty along with the satisfaction of the partner (Inkinen, 2015). The relational capital mainly encompasses all of the intangible assets that are mainly generated by maintaining, generating as well as nurturing the high-quality relationships with the external partners that can improve the performance of an organization to a great extent. There are some of the research studies that have been conducted in this particular subject matter, and it has provided the suggestion with regards to maintain the elements of the relational capital in which the organizations might have some of the advantages. On the other hand, the internal source of the relational capital refers to mainly the informal bonding with the family members (Rodrigues et al. 2017).

Organizational capital is regarded as one of the main value-contributing assets for an organization especially for the Optoelectronic industry in Taiwan. Despite the enormous benefits of the organizational capital, a lot of investment in the organizational capital is not tracked by the organizations and separated from the other investments, mainly because of the limitations with regards to the accounting system. The CEOs, as well as the other executives of an organization mainly lacks some of the reliable measures with regards to the organizational capital in terms of driving performance and managing performance (Sharabati et al. 2016).

It has been argued by a lot of researchers that in the modern competitive environment at present there is mainly a tendency that the driver of the value's creation primarily lies in the intellectual capital highly tends to affect the performance of the workers, and in the long term, it will be affecting the organization's performance to a great extent (Dženopoljac, Janoševic&Bontis, 2016). Arguably, even though the intellectual capital tends to enhance the competitiveness of the company but unfortunately, in a lot of company's human resources is said to be one of the main concerns.

There are a lot of leaders in Taiwan who are not at all aware that a company's benefit was mainly derived from intellectual capital. However, there are some of the studies that revealed the fact that human capital does not affect the performance of the workers in a significant manner. In contrast, the structural capital and consumer capital highly influences the performances of the workers.

There are a lot of researchers found out that there is a huge amount of as well as positive correlation between the expenditures of research and development (R&D) along with the performance of the business and the market value (Tulung et al. 2018). Some of the researchers have shown that when a company has a $1 enhancement in the expenditure of R&D, it has an enhancement in earnings of $2 along with the $5 enhancement in the value of market over the next seven years. According to some of the other researchers, $2.328 operating income will be brought in the future if a firm enhances the $1 expenditure of R&D (currency dollar). Another researcher stated that the intensity of the R&D, the late period technology development capability as well as the absorption of the technology capability has a positive correlation with market value-added. Throwing light on the above-mentioned studies, it can be stated that R&D expenditure of the firms not only influences present performance along with the market value but also their performances in the future.

The companies must work extremely hard to maximize the value of the intellectual capital affecting their success of the business. The diversity of the firm makes them have a different value of the intellectual capital value, e.g., consumer loyalty, innovation of the company, productivity enhancement as well as the cost reduction.

As shown in Figure 1, and what has been discussed above, the hypotheses are built as follows:

H1. Human capital positively affects innovation capital.
H2. Human capital positively affects process capital.
H3. Innovation capital positively affects process capital.
H4. Innovation capital positively affects customer capital.
H5. Process capital positively affects customer capital.
H6. Customer capital positively affects business performance.

Theoretical Framework

According to the literature review above, a research framework for this study is showed in Figure 1. This framework describes the hypothesized relationships among the constructs of human capital, innovation capital, customer capital, process capital, and business performance.
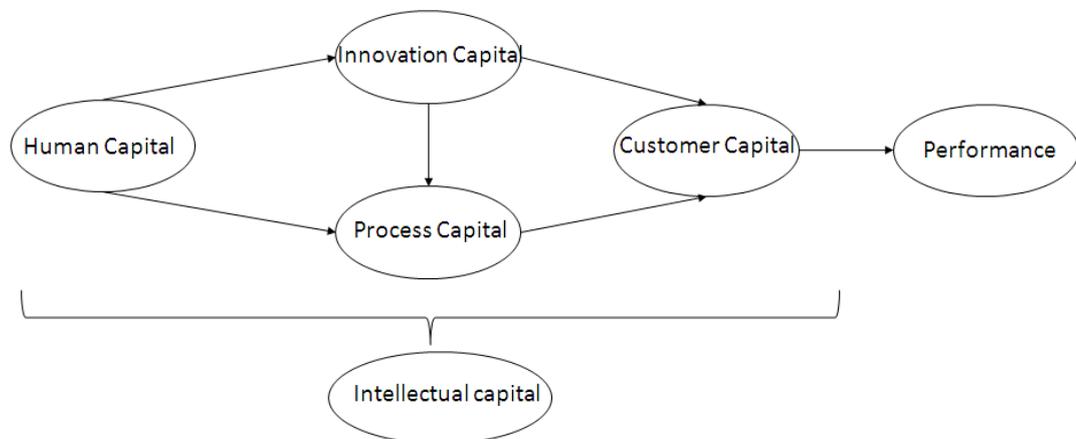

Figure 1: Theoretical Framework. Author's calculation.

Methods

This research paper adopts the partial least squares (PLS) method, and the research design can be categorized into following steps. Firstly, Data have been retrieved from the database of the Taiwan Economic Journal (TEJ) in the optoelectronic industry during the period 2014-2018.

Then, every scale item will be adopted from the literature on the measures of intellectual capital or determinants of business performance (Sougiannis, 1994; Kaplan and Norton, 1996; Lev and Sougiannis, 1996; Edvinsson and Malone, 1997; Stewart, 1997; Sveiby, 1997; Bontis, 1998; Financial Management Accounting Committee, 1998; Lee and Witteloostuijn, 1998; Bukh et al., 2001; Deeds, 2001; Mouritsen et al., 2001).

Table 1: Composition of All Variables

Business Performance	Return on assets	Sougiannis, 1994; Kaplan and Norton, 1996; Lev and Sougiannis, 1996; Edvinsson and Malone, 1997; Stewart, 1997; Sveiby, 1997;
	Return on stockholders' equity	
	Operating income ratio	
	Stock price	
Human capital	Ratio of advanced educational background	Bontis, 1998; Financial Management Accounting Committee, 1998; Lee and Witteloostuijn, 1998; Bukh et al., 2001; Deeds, 2001; Mouritsen et al., 200
	Average age of employees	
	Average years of service with company	
Customer capital	Market growth ratio	Financial Management Accounting Committee, 1998;
	Product acceptance ratio	
Process capital	Net worth turnover ratio	Lee and Witteloostuijn, 1998; Bukh et al., 2001; Deeds, 2001; Mouritsen et al., 200
	Inventory turnover ratio	
	Assets turnover ratio	
Innovation capital	R&D Expense	1996; Edvinsson and Malone, 1997; Stewart, 1997; Sveiby, 1997; Bontis, 1998;
	R&D Expense Ratio	

Finally, the data has been analyzed by the partial least squares (PLS) method with the help of Smart plus. There are 121 original samples. Although the partial regression method is suitable for small sample research, in order to be conservative, this study still uses the bootstrapping method1000 to repeatedly draw one thousand samples for parameter estimation when using the partial regression method to avoid any possible small sample problems.

Table 2: Descriptive statistics

Items	Mean	Mid	Min	Max	Std
ROA	1.002	1.01	-37.23	52.49	10.718
ROE	0.204	1.95	-88.79	86.09	19.914
Operating Ratio	-1.33	2.74	-54.84	25.47	16.383
P/B	1.527	1.23	0.35	4.44	0.937
Ratio of advanced educational background	44.264	43	9.9	87.26	22.047
Average age of employees	35.628	36	28	49	4.056
Average years of service with company	6.298	5	2	18	3.098
Net worth turnover ratio	1.893	1.72	0.12	4.47	1.199

Items	Mean	Mid	Min	Max	Std
Inventory turnover ratio	21.91	20.66	8.14	45.79	8.424
Assets turnover ratio	0.628	0.648	0.101	1.389	0.256
R&D Expense	143551.157	83478	8019	750665	146386
R&D Expense ratio	8.814	8.54	0.25	22.26	5.217
Market growth ratio	0.874	0.877	0.72	0.987	0.061
Product acceptance ratio	0.123	0.1	-0.71	1.236	0.496

Table 3: Validity and reliability for constructs

Construct	Items	Loading	AVE	CR	Cronbach's Alpha
Performance	ROA	0.957	0.783	0.934	0.904
	ROE	0.936			
	Operating Ratio	0.907			
	P/B	0.717			
Human Capital	Ratio of advanced educational background	0.821	0.752	0.901	0.836
	Average age of employees	0.897			
	Average years of service with company	0.882			
Process Capital	Net worth turnover ratio	0.868	0.689	0.866	0.77
	Inventory turnover ratio	0.648			
	Assets turnover ratio	0.945			
Innovation Capital	R&D Expense	0.871	0.771	0.871	0.704
	R&D Expense ratio	0.885			
Customer Capital	Martket growth ratio	0.848	0.798	0.888	0.757
	Product acceptance ratio	0.937			

Table 3 before conducting structural equation modeling, it is necessary to measure whether the reliability of all indicators of the measurement model conforms to the dimension. When the reliability and validity's indexes do not reach the standard, the model will be readjusted.

According to the study of Hair et al. (2006), Factor loading must be greater than 0.55, or the indicator must be deleted. After testing, you can see that all indicators are greater than 0.55, so no indicators are deleted.

According to the research by Fornell and Larker (1981), the Component reliability (CR) must be higher than 0.6. Otherwise, the oriented combination does not meet the standard. It must be discussed which indicator causes the group and the reliability not to be adjusted. It can be seen from the table that all CRs are between 0.86 and 0.93, which means that the internal consistency has reached a certain amount of water, so it is not necessary to adjust or delete any indicators.

In Convergent validity, Average Variance Extracted, AVE is the most representative. Fornell, Larker (1981), and Bagozzi and Yi (1988) suggest that the AVE of the potential variable should be better than 0.50 because it means that the potential variable is observed. The contribution of the variable is much larger than the contribution of the error (50%). After analysis, it is found that the AVE of all the facets is greater than 0.7, which means that the explanatory power of the model in all aspects is above the standard.

Cronbach's α is the most commonly used reliability index in social science research. Cronbach's alpha reliability values are between 0 and 1, and the closer the value is to 1, the higher the reliability. Measure the reliability of the sum of a set of synonymous or parallel tests (items). If all items in the scale (scale) reflect the same characteristics, there should be a real correlation between the items. If there is no correlation between an item and other items in the scale (scale), it means that the item does not belong to the scale and should be eliminated. According to (Fornell & Larcker, 1981; Gaski & Nevin, 1985) research, this value should be greater than 0.7 in practice. According to Guieford (1965), if Alpha is greater than 0.7, the reliability is quite high, and if it is less than 0.35, it represents the letter Too low. After calculation, it can be seen from the table that Alpha are all greater than 0.7, indicating that there is a true correlation between the indicators of each direction.

Table 4: Discriminant validity

	CUSTOMER CAPITAL	HUMAN CAPITAL	INNOVATION CAPITAL	PERFORMANCE	PROCESS CAPITAL
CUSTOMER CAPITAL	0.893				
HUMAN CAPITAL	0.699	0.867			
INNOVATION CAPITAL	0.659	0.642	0.878		
PERFORMANCE	0.833	0.657	0.639	0.885	
PROCESS CAPITAL	0.871	0.689	0.731	0.881	0.83

Table 4 Differential validity of each facet, Customer capital, Human capital, Innovation capital, Performance, Process capita in their own facets are greater than the coefficient of all factors related analysis of the facet, which means that each facet has different validity.

Results and discussion

Structure model

Table 5: Structure model

	p-value	Beta	t-value	Decision	f-square
H1 : HUMAN CAPITAL -> INNOVATION CAPITAL	0.000	0.642	12.534	Supported	0.702
H2 : HUMAN CAPITAL -> PROCESS CAPITAL	0.000	0.374	5.687	Supported	0.214
H3 : INNOVATION CAPITAL -> CUSTOMER CAPITAL	0.476	0.047	0.713	Not supported	0.004
H4 : INNOVATION CAPITAL -> PROCESS CAPITAL	0.000	0.491	7.679	Supported	0.37
H5 : PROCESS CAPITAL -> CUSTOMER CAPITAL	0.000	0.837	15.611	Supported	1.361
H6 : CUSTOMER CAPITAL -> PERFORMANCE	0.000	0.833	35.796	Supported	2.267

Table 5 shows that Human capital has a significant positive relationship with Innovation capital (Beta=0.642, t-value=12.534), and Human capital has a significant positive relationship with Process capital (Beta=0.374, t-value=6.687). The relationship between Innovation capital and Customer capital is positive but not significant at all (Beta=0.045, t-value=0.713). Innovation capital has a significant positive relationship with Process capital (Beta=0.491, t-value=7.679). On the other hand, Process capital has a significant positive relationship with Customer capital (Beta=0.837, t-value=15.611). Finally, Customer Capital has a significant positive relationship with Performance (Beta=0.833, t-value=35.796).

According to the above analysis results, H1, H2, H4, H5, H6 are all supported in the hypothesis of this study, only H3 is not supported. In other words, human capital will positively affect innovation capital and process capital. Innovation capital will positively affect process capital, process capital positively affects customer capital, and then positively affects performance through customer capital. If we further analyze this model that indirectly affects performance through the causal relationship between the elements of smart capital, we find that human capital is the fundamental foundation of this model. Human capital not only has a direct impact on process capital (path coefficient is 0.562), but also has indirectly influenced by innovation capital (the path coefficient is $0.458 \times 0.390 = 0.179$), the total path coefficient for process capital is 0.741, and the path coefficient for performance is $0.741 \times 0.282 \times 0.702 \fallingdotseq 0.147$. Human capital not only directly affects performance but also indirectly affects performance by affecting other factors (innovation and process capital). Therefore, the creation and accumulation of human capital cannot be ignored. If you want to improve process capital, you must also pay attention to the improvement of its leading projects-human capital and innovation capital; process capital helps the accumulation of customer capital and then promotes the improvement of performance. It can be seen from the results of this study: To improve performance efficiently, we should pay attention to the causal relationship between the elements, invest more resources, and effort on the leading elements. If we want to accumulate customer capital, we should focus on the improvement of process capital. To improve process capital, it is necessary to focus on the creation and accumulation of human capital and innovative capital.

Results and discussion

Figure 3 shows the empirical results of using partial regression to discuss the relationship between the various elements of smart capital on performance. In addition to the path of Innovation capital to customer capital, the p-value of each relevant path coefficient is less than 0.01. The results support hypothesis 1, 2, 4, 5, 6. Further analysis of this model that indirectly affects performance through the causal relationship between the elements of smart capital reveals that human capital is the fundamental foundation of this model. Human capital not only has a direct impact on process capital (path coefficient is 0.374), and will Through the indirect influence of innovation capital (the path coefficient is $0.642 \times 0.391 = 0.315$), the total path coefficient for process capital is 0.689, and the path coefficient for performance is $0.689 \times 0.837 \times 0.833 \fallingdotseq 0.481$. Human capital indirectly affects performance by affecting other factors (innovation and process capital), so the creation and accumulation of human capital cannot be ignored
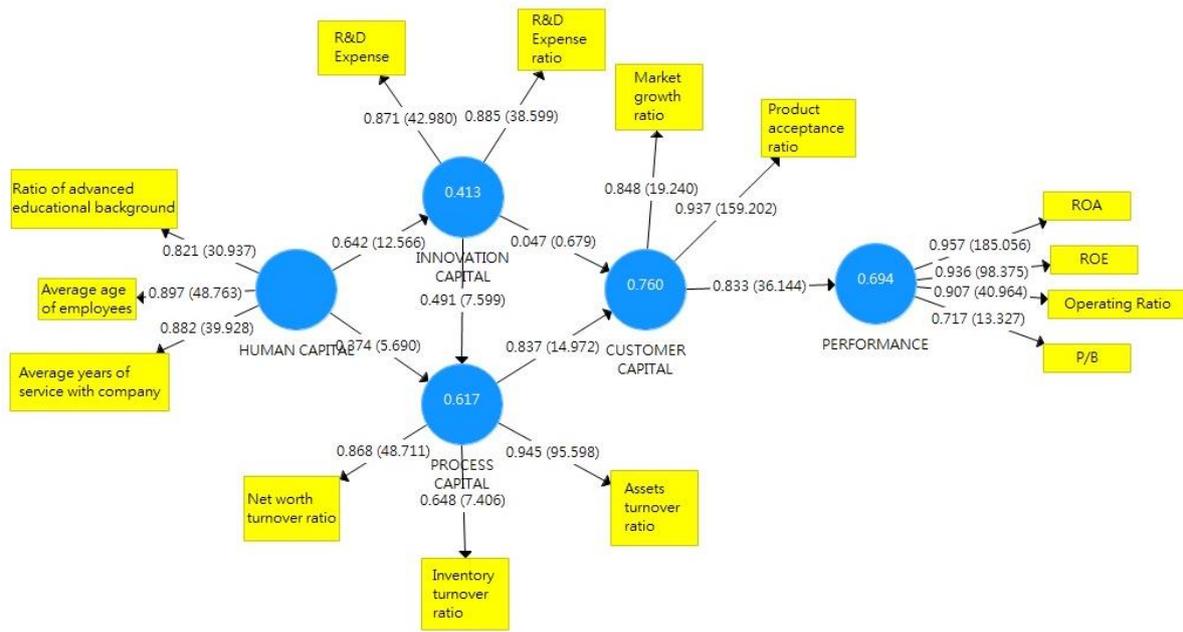
Figure 3: PLS structure model

The influence of the relationship between the elements of intellectual capital on performance

Table 6: The influence of the relationship between the elements of intellectual capital on performance

Human Capital	Average age of employees	Average years of service with company	Ratio of advanced educational background	
	0.897*	0.882*	0.821*	
	47.673	38.792	29.857	
Innovation Capital	R&D Expense ratio	R&D Expense		
	0.885*	0.871*		
	41.031	43.177		
Process Capital	Assets turnover ratio	Net worth turnover ratio	Inventory turnover ratio	
	0.945*	0.868*	0.648*	
	102.256	48.693	7.2438	
Customer Capital	Market growth ratio	Product acceptance ratio		
	0.937*	0.848*		
	156.708	19.240		
Performance	ROA	ROE	Operating Ratio	P/B
	0.957*	0.936*	0.907*	0.717*
	192.982	97.837	43.433	13.241

Table 6 represents individual elements and significant detail indicator variables of performance. The performance part is sorted according to the size of the path coefficient, namely ROA, ROE, Operating Ratio, P/B. And the significant indicators of human capital are also sorted according to the size of the path coefficient, which is average of employees, average years of service with company, ratio of advanced educational background. Hunman capital indirectly have a positive

impact on performance through Innovation capital, process capital and customer capital. It is worth noticing the two indicators of average of employees and ratio of advanced educational background. average of employees is not consistent with the original expected direction. It was believed that younger employees have more innovative ideas in all aspects to have better performance, but the result is just the opposite. Older employees can bring better operating performance. Ratio of advanced educational background reflects have professional knowledge and learning new knowledge and problem-solving skills will not only increase the external evaluation of the enterprise's capabilities but also enable the internal work of the enterprise to work efficiently and have better performance.

On the other hand, the significant indicators in Innovation capital are sorted according to their path coefficients, which are R&D expense ratio and R&D expense. Although their two indicators will not directly affect Customer Capital, they may be processed through Process Capital indirectly has a positive effect on Customer capital's operating performance, so companies should focus more on R&D expenses, which may not produce results in a short period of time, but sooner or later after the delay will show its positive impact on performance. The significant indicators of process capital are ranked as Assets turnover ratio, Net worth turnover ratio, Inventory turnover ratio according to the path coefficient, and indirectly affect the operating performance through Customer capital. From this, we can know that the effective use of the three turnover ratios can improve the turnover speed and help to improve performance. Finally, the significant indicators of customer capital are ranked according to the path coefficients: Market growth ratio, Product acceptance ratio, and Customer capital directly affect the operating performance, so the company should focus on expanding the market and increasing sales, and should reduce customer returns and cause the company's reputation. And the future repurchases rate of customers, which in turn improves business performance.

Human capital with innovation and process capital (Hypotheses 1, 2)

Among the elements of intellectual capital, human capital is the most fundamental. van der Meer-Kooistra and Zijlstra (2001) point out that human knowledge and experience is the main element, which is the base of other elements and which will impact a company's value through affecting other elements. No doubt, a skilled and efficient set of employees can come up with new ideas and provide answers to new different challenges, hence improving the sustainability and future scope of the industry. The research has clearly shown the effects of improving human capital on business efficiency with the help of Smart Plus. A significant increment of skilled staff within an industry inevitably influences the business growth of the industry. The study found a direct relationship between human capital and industrial development. The optoelectronic industry is relatively new in Taiwan; as a result, proper management of the human capital resources is a must for the further growth of the industry. The research has clearly indicated a direct relationship of the industry's growth with the betterment in human resource management.

Innovation capital with process and customer capital (Hypotheses 3, 4)

According to Lev and Sougiannis (1996), $2.328 operating income will be brought in the future if a company increases $1 R&D expenditure (currency dollar). Deeds (2001) finds that R&D intensity, the late period technology development capability, and technology absorption capability have a positive correlation with market value-added. From the above studies, it could be inferred that companies' R&D expenditure influence not only current performance and market value, but also future performance. Company puts more efforts into innovation capital, and then the product quality will be improved. Furthermore, customers will be more loyal to the company. In contrast, R&D expenditure is not significantly affected by process capital, which is long-term value.

Process capital and customer capital (Hypotheses 5)

Zeithaml et al. (1988) and Zeithaml and Bitner (1996) point out that the quality perceived by customers is the key factor of customer satisfaction. The higher the perceived quality, the more they are satisfied. Through its internal process, a company provides service quality to its customers. The improvement in process capital leads to customer satisfaction and enhancement of customer relations. Therefore, process capital is somewhat of a leading intellectual capital element, which affects customer capital element, while the customer capital element, in turn, influences financial performance.

Customer capital with business performance (Hypotheses 6)

Fornell et al. (1996) propose the American Customer Satisfaction Index and contend that customer expectations, perceived quality, and perceived value could influence customer satisfaction. Since customer expectations and perceived value are not controllable, a firm's primary task to enhance customer satisfaction is to increase perceived quality. The software application and data analysis sections in the research have clearly indicated the direct relationship between customer capital resources and the growth of Taiwan's optoelectronic industries. The research has also established a relationship between the indirect effects of different resources on industry growth.

Conclusion

The core aim of the research was to establish the recent emergence of the optoelectronics industries with the influence of multiple intellectual resource factors on the industry. The researcher has effectively met all the research objectives by clearly discussing every aspect of intellectual capital in the Taiwan optoelectronic industry. The research has also established a profound relation between structural resources and industrial growth. These results above suggest that human capital has a positive impact on innovation capital, and also process capital. Moreover, innovation capital and process capital positively affect customer capital. In the end, customer capital significantly affects business performance. On the contrary, innovation capital has insignificantly effect on process capital. The hypothesis which is made by the researcher that intellectual capital helps a business to flourish more is appropriate, as this has made firms to boost their productivity level. This has enabled the companies to enhance competence and capability in the organizations as it is evident from many studies that the employees with having enough skills and capabilities are responsible for sharing various ideas and increasing the competency within the organization.

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