Canola Council
Final Report

2016-24
Can We Replace Soya Sauce with Canola Sauce?

Summary

A mixture of Manitoban canola meal and roasted wheat were fermented with a commercial soy “koji” culture in the traditional soy sauce process. A light coloured canola sauce was produced with a similar taste and aroma profile to commercial soy sauce. Limited taste testing was favourable to the canola:wheat sauce.

Introduction

Soy sauce is a condiment produced from soy beans and from soy meal which is consumed on an extremely large scale. As much as 10 billion litres of soy sauce are produced each year requiring several million tons of soy beans and/or defatted soy meal. In the traditional process whole soy beans are steamed, crushed and mixed with an equal amount of roasted wheat and then inoculated with selected strains of the fungus *Aspergillus oryzae* or *Aspergillus sojae*. Over a 3- 5 day incubation the fungi grow spreading through the substrate and forming a mat. This “koji” is then crumbled and added to an18% salt brine. The koji fungi produce enzymes, notably proteases, lipases and amylases, which then act breakdown the proteins, lipids and starch of the soy beans and the wheat. The fungi cannot live in the anaerobic brine solution but yeast and bacteria can. These microorganisms ferment the simple sugars produced by enzyme activity upon the starch and other polysaccharides of the soy beans and wheat. The fermentation products are mostly ethanol and lactic acid but several other alcohols, organic acids and esters are produced. In addition amino acids and fatty acids from the proteins and lipids react to form hundreds of other flavor and aroma compounds. Other compounds are produced by chemical reactions, the Amadori and Maillard reactions. This fermentation process is slow taking 6 – 12 months in traditional, artisanal soy sauce production but is performed considerably faster on an industrial scale, days to weeks.

Fermented bean condiments and foods are not necessarily restricted to using soy beans as their starting material. Even in China black beans and broad beans are fermented into specialty condiments. Substituting other oilseeds for soy is even more widespread in traditional African fermented foods. Ogiri, popular in west African countries, is a condiment produced from fermented sesame or egusi seeds. Irú, popular in Nigeria, is fermented locust beans (*Parkia biglobosa*) used as a condiment in cooking. In India dhosas and idli are prepared from fermented black lentils, chickpeas and other seeds. Kanji is a beverage produced form fermented mustard seeds. There seems to be no reason that canola seeds could not be substituted for soy beans in the production of soy sauce. In addition there does not seem to be any reason that canola could not be substituted for any other seed in traditional fermented foods.

The purpose of this project was to determine whether canola meal can be fermented into a soy sauce-like product or whether a fermented canola meal product could be produced which would be a novel condiment or food product. We fermented a mixture of canola meal and roasted wheat in the traditional soy sauce process and produced an acceptable soy sauce-like condiment.

Materials and Methods

Canola meal was obtained from the Viterra plant in Saint Agathe, Manitoba. This is a screw-pressed meal rather than a solvent extracted meal with a slightly higher than usual residual oil content (8%). This canola meal was used with no further processing except for one trial when the meal was extracted twice with hexane and dried to remove residual solvent. Wheat was obtained from ADM (Winnipeg) and stored at room temperature until use. Rice, rice bran, wheat bran, and frozen soy beans were obtained from local food retailers and stored until further use. Various types of koji were prepared including a conventional soy bean:wheat blend, a soy bean:rice blend, a canola:rice blend, a canola:wheat bran:wheat blend, a canola:green wheat blend, a canola:cracked oats blend, and a hexane defatted canola:wheat blend. Before incorporation into the production of canola:wheat sauce this wheat was roasted at 350°C for 30 minutes in a commercial electric oven, cooled, cracked using a commercial food processor, and stored in plastic bags until used. Most experiments used a 50:50 weight ratio of canola meal and cracked roasted wheat rice or bran.

For the experiments to actually ferment the koji for a 6 – 8 month period a 50:50 weight ratio of canola meal and cracked roasted wheat was chosen as the staring material. After mixing the canola meal and wheat by hand in a 12” x 18” enameled steel tray the mixture was autoclaved at 121°C for 15 minutes then cooled to room temperature. This mixture was inoculated with 250 g of a commercial koji “Organic Brown Rice Koji” obtained from Cultures for Life (Morrisville, NC, USA). The weight of the canola:wheat mix was approximately 2 kg. The inoculated mix was incubated at room temperature for 3 to 4 days with daily addition of water sprayed on the surface. When the koji had spread through the canola:wheat mix it was broken up by hand and placed in a polyethylene bucket. The mix was then covered with 18% salt (NaCl) brine. A 250 mL culture of *Zygosaccharomyces rouxii* and a 250 mL culture of *Tetragenococcus halophilus* were added to the brine/koji and the lid, equipped with a wine making fermentation lock, was placed on top. Fermentation continued at room temperature for 6 months. Three separate preparations of this canola:wheat “koji” were undertaken on three separate dates due to equipment and space limitations. Sampling took place at various times. A 20mL sample was taken using a pipet. For counting microorganisms a log dilution series in 0.1% peptone broth was performed. Samples were then plated onto SAB + chloramphenicol, SA, MRS, and enriched TSA to count yeast (*Zygosaccharomyces rouxii*), *Tetragenococcus halophilus,* lactic acid bacteria, and all bacteria respectively (see appendix for formulation of media). Samples were also assayed for the concentration of free amino acids using a colourmetric ninhydrin assay (Sigma-Aldrich, Ninhydrin reagent, 2%, N7285) following the manufacturer’s instructions. The free amino acid assay was used to monitor the digestion of canola and wheat protein in the fermenting koji. At the end of the fermentation large volume samples were taken, filtered through a paper filter, filtered through a membrane filter and then either pasteurized (70°C for 4 hours) or autoclaved (121°C for 15 minutes) before use in a taste testing. A small panel (n=5) of tasters first sampled 8 commercial fermented soy sauces obtained from local retail establishments. After blind tastings and recording of evaluation all three canola:wheat fermented and pasteurized sauce where evaluated in a blind tasting.

To start this project we attempted to produce soy sauce in the traditional Japanese fashion. Fresh, frozen soy bean were thawed and crushed and weighed. An equal weight of roasted, cracked wheat was added to the soy beans and mixed. The commercial “koji” starter was mixed into the soy:wheat blend. The inoculated mixture was place into an enameled steel pan, covered with aluminum foil and incubated at room temperature for 4 days. When the *Aspergillus oryzae* had grown through the soy:wheat mixture it was crumbled and submerged in an18% salt (NaCl) brine. This was then placed in a bucket with an airlock and allowed to ferment for 6 months.

Figure 1: Bucket and air-lock used in canola:wheat blend fermentation.

Results

Several trials were undertaken to find the appropriate conditions and substrate composition for the production of a canola:wheat “koji”. As a comparison frozen green soy beans were purchase, mashed and mixed 50:50 by weight with cracked, roasted wheat. The commercial “koji” starter was added, 250 g to 2 kg of soy bean:wheat mixture. After 3 days of incubation a good growth of the *Aspergillus* fungi throughout the soy bean:wheat mixture was obvious by the colour and visual observation of fungal mycelia growing through and cementing together the soy beans and wheat grains. With the successful production of a soy bean koji we attempted to substitute the soy beans with canola meal. Canola meal was mixed with cracked wheat 50:50 by weight and inoculated with the same commercial “koji” starter culture. In contrast to the soy bean “koji” little growth of the *Aspergillus* fungi was seen even after a week of incubation. We then attempted to produce a canola koji with other substrates including bulgar wheat, freekeh (green wheat), wheat bran, cracked oats, and cooked rice. Little success was obtained. Noting that there was growth of some fungi in the canola:rice mixture which was quite wet compared to all the other canola combinations we began autoclaving the canola mixtures to both reduce the number of competing microorganisms in the substrate before adding our commercial “koji”starter culture and to increase the amount of moisture in the canola mixtures.

Figure 2: Successful “koji” after growth of *Apergillus* through the canola:wheat blend

Free Amino Acids Concentrations During Fermentation

The presence of free amino acids is an indication of proteolysis. In this case the concentration of free amino acids indicates that canola meal proteins and wheat proteins are being broken down to peptides and amino acids by the enzymes produced by the *Aspergillus* fungi inoculated into the canola meal:wheat “koji”. Initial concentrations of free amino acids were about 5 mg/L but rose rapidly to between 15 and 20 mg/L within the first 4 weeks. After that point the concentrations fell and remained at about 15 mg/L for the rest of the fermentations. The initial increase in free amino acids is almost certainly due to the proteolytic enzymes produced by the *Aspergillus* fungi. In the future we could verify this by assaying the fermentation for proteolytic enzymes rather than for the concentration of free amino acids. Amino acids have 2 functions in the fermentation of soy or canola sauce. One function is to support the growth of yeasts and bacteria in brined koji and the other function is as a precursor of various amines which contribute to flavour and aroma particularly to the “unami” or meaty/savoury aspect of sauce flavor. This flavor aspect is reinforced by the growth of yeasts and bacteria in the brine as they also produce flavor and aroma compounds.

Populations of Microorganisms During Fermentation

Once the koji is submerged in the 18% salt solution few microorganisms can survive. Those which do include salt-tolerant yeasts, lactic acid bacteria, and, specifically salt-tolerant bacteria such as *Tetragenococcus halophilus.* After addition of the koji to the brine *Zygosaccharomyces rouxii* and *Tetragenococcus halophilus* were inoculated into the mixture. Lactic acid bacteria are part of the natural flora in the koji.

The population of yeasts (*Zygosaccharomyces rouxii*) was relatively low starting at about 3 x 10^3 cells/mL, increasing to about 1 x 10^4 cells/mL at 5 months fermentation, and declining to about 4 x 10^3 cells/mL at the end (7.5 months) of fermentation.

The population of lactic acid bacteria was much higher staring at about 8 x 10^5 cells/mL, then slowly declining to about 1 x 10^4 cells/mL by week 12 and rising to between 7 and 10 x 10^4 cells/mL over the course of 7 months fermentation.

The population of *Tetragenococcus halophilus* which grew specifically on SA medium began at 5 x 10^5 cells/mL, remained at the 10^5 cells/mL level for 4 weeks, then declined to the 2-4 x 10^4 cells/mL level over the last 6 months of the fermentation.

Figure 3. Example of growth on SAB + chloramphenicol medium for the enumeration of *Zygosaccharomyces rouxii* and other yeast.

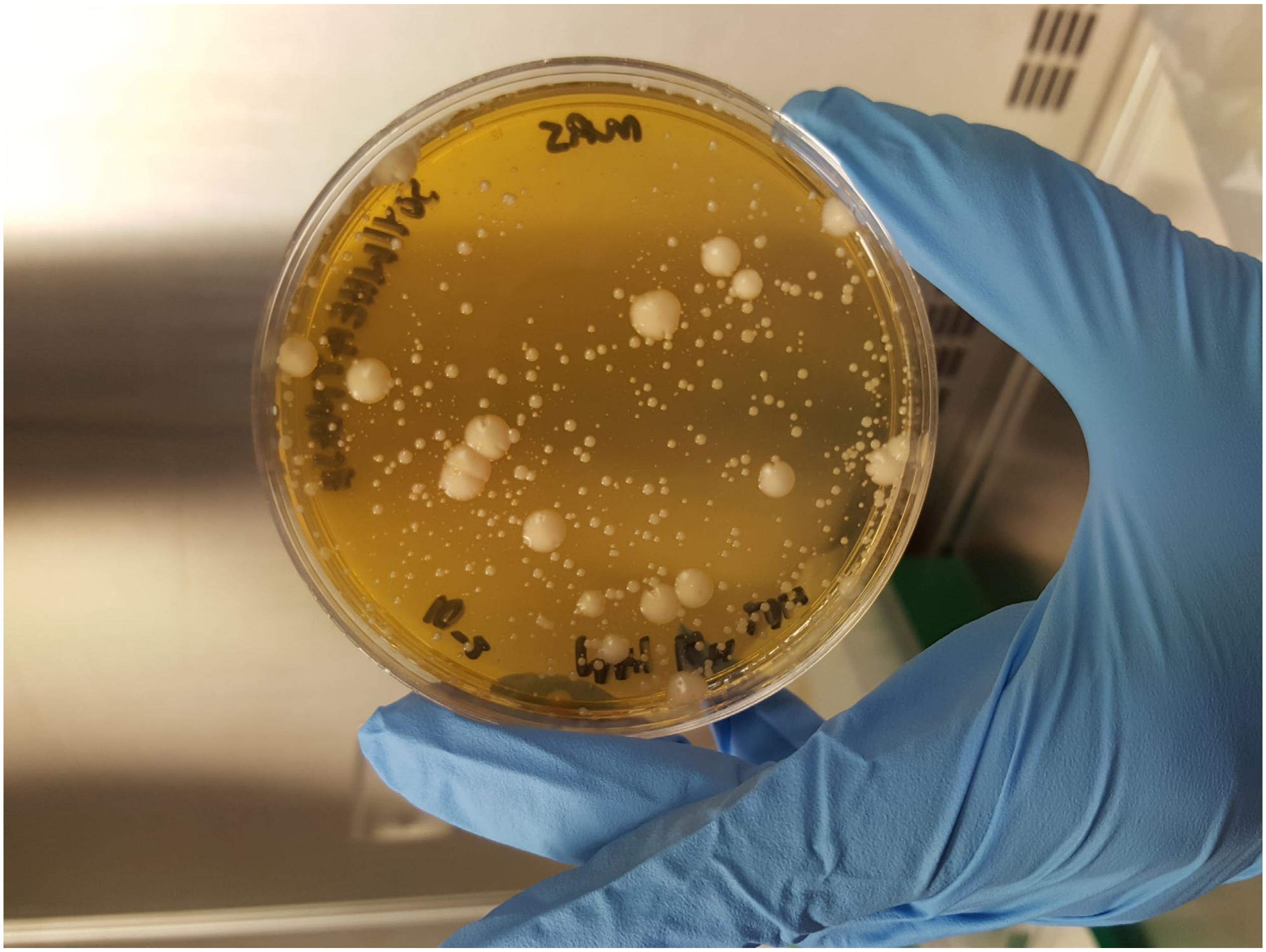


Figure 4. Example of growth on MRS medium for the enumeration of lactic acid bacteria.

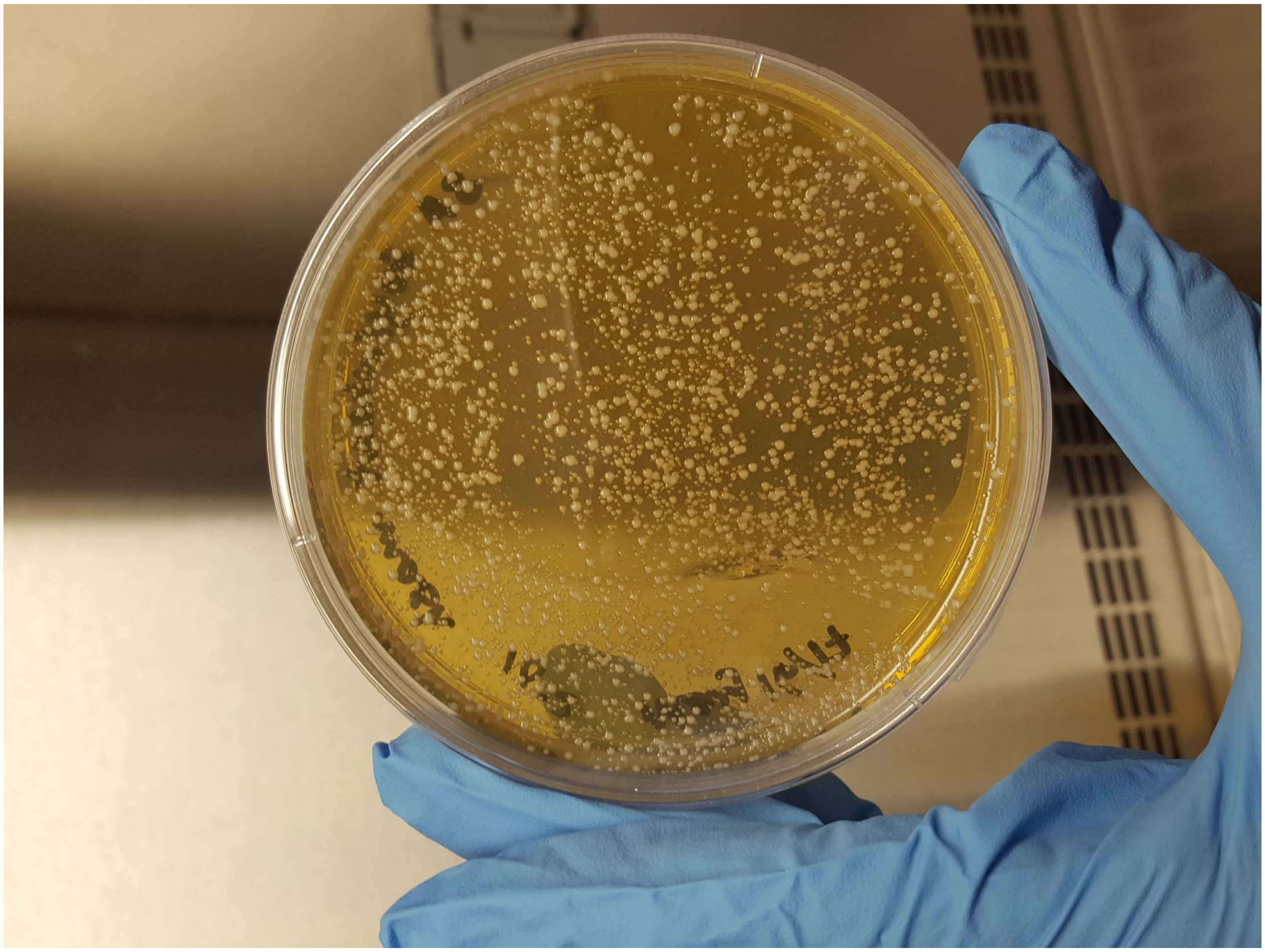


Figure 5. Example of growth on SA medium for the enumeration of *Tetragenococcus halophilus*

Flavour and Aroma Evaluation of Canola Sauce at the End of the Fermentation

Canola meal should ferment in the same way that soy beans and meal does to produce a condiment. However, this means little if the taste and aroma in not acceptable. We conducted a small, untrained taste and aroma evaluation using lab personnel and other students. As a baseline evaluation of the taste and aroma of a number of commercial soy sauces was undertaken. Eight were chosen on the basis that they had to be "naturally" fermented and contain soy and wheat. Samples were evaluated on intensity of attributes on a 10 point scale, 10 being the most extreme. There was considerable variation in the aroma and tastes of the 8 commercial soy sauces with considerable differences in the panel's overall liking of the commercial soy sauce. Thus whatever the taste and aroma profile of a canola product there is likely to be a range of reactions to its attributes.

Figure 6: Samples of a canola:wheat blend fermentation after filtration and pasteurization (left) and the same sample with the addition of a commercial food dye (right).

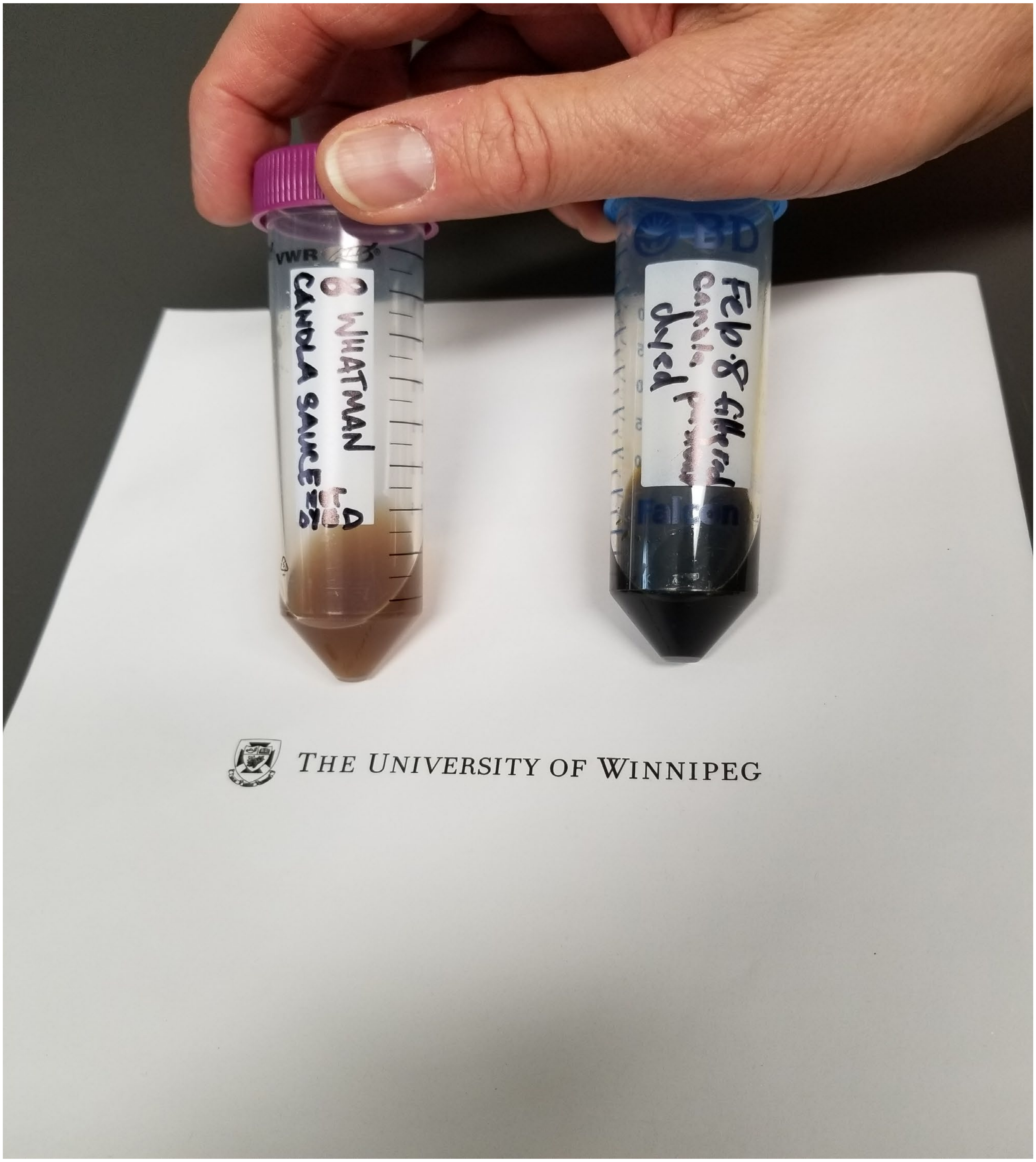
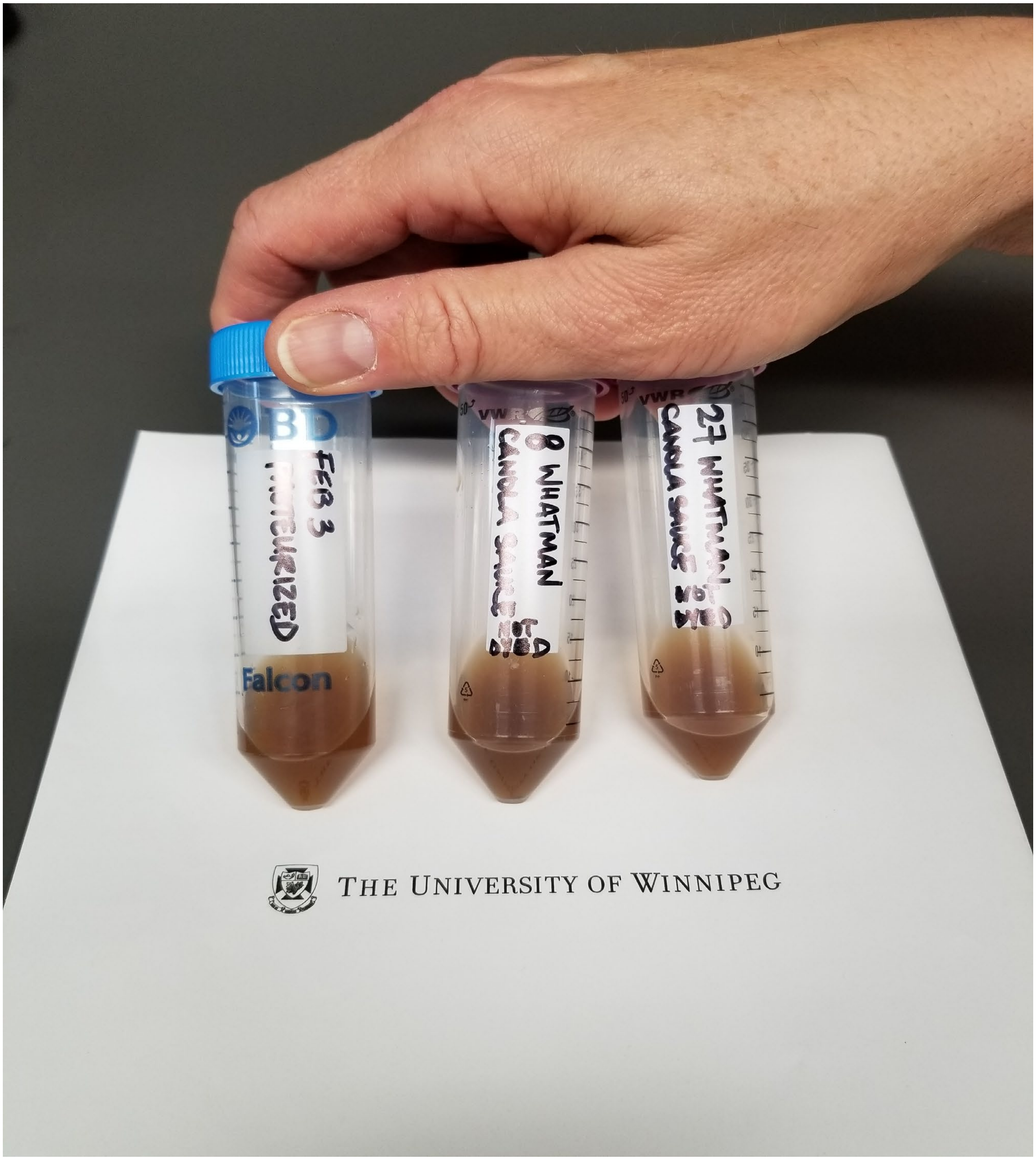


Figure 7: Samples of the 3 trials of canola:wheat blend fermentation after filtration and pasteurization.



Discussion

Soy sauce production is one of the largest food fermentations in the world and one of the largest traditional uses of soy beans for human consumption. In addition to the desirable taste and aroma properties of soy sauce this condiment this also provides vitamins, minerals, and a certain amount of protein (amino acids) to the diet. Given the similarity between soy beans and canola seeds in their composition of protein, lipids and carbohydrates there does not seem to be any *a priori* reason that a similar condiment type sauce could not be fermented from canola or pressed canola meal. If we had only invented canola 2,000 years earlier we might be seasoning our steaks and rice with canola sauce today. This project was an attempt to produce a condiment type sauce from canola meal using traditional Japanese soy sauce technology which employs a long (6 -18 month) fermentation of a modified soy (canola) base along with toasted wheat for colour and fermentable carbohydrates. Salt provides the preservative and prevents the overgrowth of the fermenting mixture by fungi and kills pathogenic bacteria. This is assisted by the fermentation of carbohydrates to lactic acid, acetic acid, and small amounts of ethanol. In addition lactic acid bacteria and halotolerant yeast exclude and probably inhibit other types of microorganisms from growing and spoiling the soy (canola) fermentation. As well as the traditional fermentation much “soy sauce” is produced from soy beans or meal and wheat by mineral acid hydrolysis and heat. This soy sauce is considered to be inferior to traditional fermented soy sauce in taste and aroma but is much cheaper to produce. There is also a high temperature, short time fermentation process where a soy meal:wheat slurry is passed through several consecutive columns each containing a population of a different type of immobilized microorganism. These columns are populated with lactic acid bacteria and two species of yeast which produce the acidity, ethanol, and taste and aroma compounds. This process takes only 3 days and produces a soy sauce superior to acid hydrolysis but inferior to traditional fermentation. It is not apparent how widespread the use of this accelerated fermentation technology has become.

Koji Preparation

The basis for the traditional fermentation is the preparation of the koji. Bacteria and yeast cannot directly use proteins, lipids and complex carbohydrates; they must be broken down into amino acids, fatty acids, and monosaccharides. Fungi secrete enzymes which break down biological polymers. Over time strains of *Aspergillus oryzae* or *Aspergillus sojae* have been selected for superior ability to break down proteins and carbohydrates and for the lack of toxicity to humans. These are the strains now used in traditional soy fermentations. After inoculation of the prepared bean:wheat mixture the fungi grows through the material, it’s hyphae gluing the grains together into a block while secreting the enzymes. Two to 4 days growth is sufficient to produce enough enzymes to break down the proteins and carbohydrates, after this point there is no need to further grow the fungi. Submerging the koji in an18% salt brine and allowing the mixture to become anaerobic halts the growth and ultimately survival of the *Aspergillus* fungi. Over time the secreted enzymes breakdown protein as indicated by an increase in the free amino acid concentrations measured by the ninhydrin assay. To start this project we attempted to produce soy sauce in the traditional Japanese fashion. In this mixture the commercial “koji” starter culture performed well and grew throughout the substrate in about 4 days. We then attempted to produce a “koji” with canola meal and wheat. This was not successful, the starter culture failed to grow and other bacteria and fungi took over and spoiled the substrate. In case this result was due to a relative lack of carbohydrates which could be used by the *Aspergillus oryzae* we substituted steamed rice for the wheat component. This was also unsuccessful. Thinking that the oil component of the canola might be excessive since this was pressed rather than a solvent extracted canola meal we hexane extracted the canola meal, removed the solvent and produced a new canola:wheat blend with poor results. We repeated these experiments with wheat bran, green wheat and cracked oats mixed with canola meal. These experiments also gave poor results, the growth of *Aspergillus oryzae* was weak as compared to the soy:wheat blend. Finally we switched the commercial “koji” starter to another more expensive product which worked as well in a canola meal:wheat blend as it did with the soy:canola blend. This particular starter culture was used for all subsequent fermentations. In addition we began to autoclave the canola:wheat blend before inoculation. We reasoned that this would reduce the competition from other microorganisms and allow the starter culture to grow faster and autoclaving also wetted the roasted cracked wheat more thoroughly and aided in its breakdown by the *Aspergillus* fungi. These modifications provided a suitable canola:wheat koji which was used in the following fermentations.

Fermentations

Due to space limitations 3 separate fermentation trials were conducted. The canola:wheat substrates were prepared and inoculated separately over a 3 week period. After koji preparation each mixture was submerged in 18% brine in a separate bucker with airlock and allowed to ferment at room temperature for about 7 months. Samples were taken with declining frequency for counting the microorganisms and measuring the free amino acid concentrations. The population of lactic acid bacteria was the highest of all types of microorganisms which given the starting material (plant material), the high slat concentration, and the anaerobic conditions of the fermentation is typical. Lactic acid bacteria populations were relatively low (10^5/mL) and did not rise by much during the fermentation. This reflects the inhibitory nature of the fermentation, the very high salt concentration and the lack of monosaccharides (glucose) and amino acids present. Lactic acid bacteria cannot breakdown proteins and complex carbohydrates and must rely on the enzymes produced by the *Aspergillus* starter culture to do so for them. It may also be that canola protein breaks down in different ways than soy protein and lactic acid bacteria find it difficult to obtain enough nitrogen for extensive growth. While the commercial starter culture grew well through the canola:wheat blend it may not produce proteases which are efficient in feeding the lactic acid bacteria. Further investigation into the suitability of this or other *Aspergillus* starter cultures or even the use of commercial proteases may be necessary to increase the efficiency of the lactic acid bacteria fermentation.

Zygosaccharomyces rouxii is a salt-tolerant yeast which ferments glucose to ethanol. Traditionally fermented soy sauce typically contains 1 to 2% ethanol. This ethanol suppresses other unwanted microorganisms and also contributes to the production of aroma compounds. In establishments were soy fermentations have been conducted for long periods of time *Zygosaccharomyces rouxii* and other distinctive microorganisms are present in the buildings and on the equipment and naturally enter into the fermentation. In a lab with no tradition of soy fermentation these organisms must be provided. The population *Zygosaccharomyces rouxii* was low during the entire fermentation. The population at inoculation was about 3×10^3 cells/mL. There was some reproduction of this yeast as the population increased to about 1×10^4 cells/mL at 5 months then declined to about 4×10^3 cells/mL at the end of fermentation probably as a result of lack of nutrients. It is difficult to say whether the population of *Zygosaccharomyces rouxii* in the canola fermentation was exceptionally low as little quantitative data is available for this yeast in these types of fermentations.

Tetragenococcus halophilus is a species of lactic acid bacteria which seems to be specific to soy sauce and other high salt fermentations (fish sauce for example). *Tetragenococcus halophilus* is believed to contribute aroma and taste compounds to the fermentation in addition to fermenting glucose to lactic acid. SA medium is selective for *Tetragenococcus halophilus.* Counts on SA began at 5×10^5 cells/mL, remained at the 10^5 cells/mL level for 4 weeks, then declined to $2\text{-}4 \times 10^4$ cells/mL over the last 6 months of the fermentation. Again it is difficult to know whether this is a low or abnormal number of *Tetragenococcus halophilus* cells due to the lack of quantitative data however the presence of this bacterium is generally correlated with positive aroma qualaties. Also in a lab with no tradition of soy fermentation *Tetragenococcus halophilus* must be provided to the fermentation.

Flavour and Aroma Evaluation of Canola Sauce

A canola sauce condiment either has to compete with soy sauce or present a new taste/aroma profile that consumers would find appealing. As an initial evaluation of flavor and aroma we used a panel of 5 students and workers. During a training session 8 commercial fermented soy sauces were evaluated both on a numeric scale and by taste/aroma descriptors. The finished canola/wheat blend fermented product was filtered and pasteurized or filtered and autoclaved and used in a taste/aroma evaluation. The most obvious difference between soy sauce and canola source was the colour. Soy sauces range from dark brown to black in colour. Our canola sauce was a light brown. Sensory evaluation ranked canola sauce inferior to soy sauce based on colour. It is thought that most of the colour in soy sauce originates from the toasting of the wheat which was very mild in the case of our canola sauce. Further trials with various times and temperatures for roasting wheat should be undertaken to determine whether more intense roasting would increase the darkness of the finished product. Colour darkens upon heating. We both pasteurized the canola sauce as this is standard procedure for commercial soy sauce and autoclaved the canola sauce in an attempt to darken the colour by increasing the temperature the sauce is exposed to (121ºC vs 85ºC). This was not successful and we were concerned about changing the flavor profile if heating was more extreme. It should be noted that commercial food products can be made darker by the addition of dyes and caramel.

The flavor and aroma profile of canola sauce was evaluated as better than the colour, at least in 2 of the 3 trials. The third trial had a distinct aroma of the raw “koji” which was rated as unpleasant. The other 2 trials of canola sauce fermentation were generally regarded as similar but less intense in aroma and taste. Viscosity and aroma intensity of fermented canola sauce were both rated lower than most commercial soy sauces. This probably reflects the ratio of koji to brine at the beginning of the fermentation. In buckets it was difficult to judge whether the koji would be submerged since it floats on a dense 18% salt solution. We probably used too high a volume of brine so that flavour and aroma compounds and compounds which increase viscosity (non-digested carbohydrates and proteins) were diluted. Further work on this fermentation should be done in appropriate transparent glass bottles or with weights similar to those used in sauerkraut fermentations to achieve higher “koji” to brine ratios. It was noted that there were elements of “cold-cuts” aroma which presumably reflects the fact that meat products such as salami are fermented with lactic acid bacteria and contain some of the same aroma compounds, the same reason that “miso” aroma notes were detected. Overall canola sauce was rated as “soy sauce lite” but agreeable.

Conclusions

We have fermented a canola meal based substrate into a condiment resembling a light soy sauce. Aroma and taste evaluation was positive. With additional work into the details of the fermentation a more substantial soy sauce replacement could be produced. This may allow the development of a fermented canola based food/food product industry which would require supplies of canola meal rather than the oil itself.

The basis for a traditional soy sauce fermentation, a “koji” of canola meal and toasted, cracked wheat was produced. This “koji” possessed sufficient enzymatic power to provide substrates for the following fermentation. We did not directly evaluate the proteolytic, lipolytic, and amylolytic enzyme capacity of the “koji” but relied on the success of the fermentation. The starter culture used for this project was a commercial Japanese product. This may not be the optimal culture for a canola based “koji”. A future project would be to evaluate other commercial starter cultures and other isolates of *Aspergillus oryzae* or *Aspergillus sojae* for superior growth and enzyme production in canola meal based substrates. In addition wheat may not be the best source of carbohydrates for these other cultures. When a superior strain of *Aspergillus* is identified then trial fermentations with other grains or sources of carbohydrates could be tested to determine the best partner substrate for canola meal. In addition various ratios of “koji” to brine need to be investigated to increase the viscosity and aroma/taste attributes.

More than 300 individual chemical compounds have been identified as part of the aroma and taste profile of soy sauce. In particular 4-hydroxy-5-ethyl-2-methyl-furone (HEMF), several other furones, and the alcohol, 2-phenylethanol, have been implicated as the most important aroma compounds. All of these compounds can be extracted and measured to give a more quantitative analysis of the canola fermentation and to determine which fermentation factors influence the soy sauce-likeness of a canola fermented product. To measure these compounds an extraction process and a gas-chromatograph-mass spectrometer are required. Therefore the effect of fermentation parameters could be evaluated chemically and by sensory evaluation.

One of the assumptions of this project is that we are developing a canola based soy sauce. It is possible that a lactic acid bacteria/yeast fermentation of a canola based substrate could produce a novel product, either a condiment or a food product (ex. miso), which is distinct from soy sauce and desirable in its own rights. To develop a canola based fermentation along these lines would require the experience an cooperation of the University of Manitoba Food Science department and/or the Food Development Centre but could result in a unique Canadian food product of value to canola farmers and processors.

Appendix

Microbiological Media

Enriched TSA

30 g Tryptic Soy Broth
5 g Yeast Extract
5 g NaCl
15 g Agar

SAB + Chloramphenicol Agar

1L SAB broth
25mg Chloramphenicol / 1mL 95% Ethanol
1mL Chloramphenicol in Ethanol / 1L SAB

Sodium Acetate Agar

16.5 g Sodium Acetate
5 g Glucose
1.5 g Yeast Extract
5 g Tryptone
2.5 g Potassium Phosphate Dibasic
2.5 g NaCl
7.5 g Agar
500mL distilled water.

MRS Agar

10 g Casein peptone
8 g Meat extract
4 g Yeast extract
20 g Glucose
1 g Tween 80
2 g $(NH_4)_2$ citrate
5 g Na acetate
15 g Agar
1 L distilled water
pH 5.7

Taste Panel – Evaluation of Canola:Wheat Fermented Sauce

Scale of intensity from 1 (weakest) -10 (strongest)
Average of 5, qualitative remarks collated

Commericially produced but fermented soy sauces

Kikkoman Traditionally Brewed Soy Sauce
Strong, wheaty, salty, typical soy sauce, good aftertaste
Viscosity (thickness) - 7
Aroma (strength) - 8

Kung Fu Soy Sauce
Similar to 1, but very weak; more acidic than 1, good aftertaste
Viscosity - 5, fairly light, not as dark as Kikkoman, thinner than Kikkoman
Aroma - 4

Lee Kum Kee Premium Soy Sauce
Smells/tastes like sour pickles (as opposed to sweet pickles) or sauerkraut, vinegary, very acidic, tongue-tingling, aftertaste is okay
Viscosity - 7
Aroma - 7

Tam Thai Tu Soy Sauce
Tastes is strong, smells/tastes like sweet corn or creamed corn or barley, very smooth, great aftertaste
Viscosity - 8, more viscous than Kikkoman
Aroma - 8

Pearl River Bridge Superior Dark Soy Sauce
Very strong, delivers the biggest punch, BBQ sauce, HP sauce or thick, fortified wine?
Viscosity - 9
Aroma - 9

Coconut Brand Naturally Fermented Premium Soy Sauce
Aroma = similar to Tam Thai Tu, but weaker, corn-like, sweet; taste = not good, yeasty, bad after taste
Viscosity - 7
Aroma - 5.5

Silver Swan Special Soy Sauce
Whole wheat bread, wheaty, similar to Kikkoman, might be saltier than Kikkoman, mild after taste
Viscosity - 7
Aroma - 7

Pearl River Bridge Superior Light Soy Sauce
Sour wine smell; tongue-tingling, sour, acidic, weak in smell, taste and aftertaste
Viscosity - 4
Aroma - 5.5

Canola:Wheat Fermented Sauce Produced in this Study

Our Soy Sauce

Similar to Silver Swan, but weaker in taste, wheaty, buttery, light, slightly acidic, salty kick to it, mild aftertaste, also not the worst tasting soy sauce!

Viscosity - 6, black in colour

Aroma - 6

Canola Sauce - Feb 3 Trial

Aroma meaty - sausage-like or sweet coldcuts, sweeter than our soy sauce, very light in colour (tan), saltier when refined (Whatman + 0.45 um filter)

Tastes like miso soup, quite salty, MSG

Viscosity - not black in colour, thin?

Aroma - 6

Canola Sauce - Feb 8 Trial

Aroma /tastes koji-like, bad cheese?, unpleasant, taste lingers, darkest of the 3 canola meal samples, but still v. light (tan)

Viscosity - not black, thin?

Aroma - 7, pungent koji smell

Canola Sauce - Feb 27 Trial

Weaker in aroma and taste, wheaty smell, similar to our soy sauce, sour miso soup or coldcut taste, weaker than feb 3 and feb 8, light in colour (tan), colour between Feb 3 & 8

Viscosity - not black, thin?

Aroma - 4