Boarding the rice bran bandwagon

Part 2: A natural ingredient for meat formulations combining a vast plethora of advantages

The first part of this publication released with FLEISCHWIRTSCHAFT International 6/2009 dealt with general aspects and characteristics of rice bran usage in the food chain. This article shows that the emergence of rice bran, which contains nearly 29% total dietary fibre, provides not only beneficial physiological effects but also technological advantages – including offsetting the negative texture and flavour impact of fat reduction. It also highlights that stabilised rice bran has great potential to develop into successful business propositions for food and meat applications.

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Rice bran contains a dietary fibre with functional physico-chemical, sensory and textural values in both emulsified and coarse-ground meat products. The ingredient has proven its ability to offset the detrimental effects of high soy protein inclusion levels in meat products. For such products, such as chicken patties, 1% to 2% stabilised rice bran results in a significant decrease in cook loss and improvements in juiciness and texture. Rice bran causes no adverse effects on colour, flavour or bite, although it’s fair to note that at increasing inclusion levels, rice bran has a tendency to develop a slight off-white colour in all-breast meat chicken formulations.

For the sake of a clear understanding, it’s important to agree on the definition of a meat emulsion. A meat emulsion, fine fat droplets are dispersed in an aqueous medium containing soluble proteins, other soluble muscle constituents, segments of muscle fibres and connective tissue fibres. In a stable emulsion, each fat droplet is coated with a thin layer of soluble protein, which has been released into the aqueous medium from the muscle fibres.

It is known that myosin and actomyosin in a meat emulsion largely determine the quality and strength of binding and structure. Besides the role of salt and phosphate in creating optimum amounts of salt soluble protein (SSP), also heat treatment is an important variable. It has been reported that slow heating rates allow more protein-to-protein interaction and thus form a more coherent and stronger 3-dimensional gel or matrix. Because of price competition and affordability, over the past 30 years, many meat processors have rather aggressively reduced the inclusion level of lean meat and/or substituted with less technologically favourable meat cuts or introduced mechanically deboned meat from least cost options such as chicken or turkey. Subsequently, to offset the less availability of the high performing meat proteins for meat emulsion structure and stability, supporting ingredients such as soy isolate or soy concentrate, starches and hydrocolloids have been successfully introduced to augment or enforce the myofibrillar meat proteins. Despite reliable and good performance properties of soy ingredients in emulsified meat products, antagonistic behaviour develops in texture when increasing amounts of meat is replaced.

Even within the soy protein isolate category, relatively huge performance differences can be observed. For example, high-gelling soy isolate is better suited for low protein content and stretcher meat formulations. On the other side, low-viscosity soy protein isolate or soy concentrate is better suited for high meat content sausages, albeit at lower levels of inclusion. In other words, high-gelling soy isolate for high meat replacement and low-gelling soy isolate for low meat replacement.

Since rice bran cannot be con-
force the emulsion or meat batter with increased levels of functional ingredients. For these products, soy isolate or concentrate and stabilised rice bran can be considered synergistically - when properly applied, soy isolate or concentrate can provide a mechanism to reduce surface tension at the fat:water interface, while stabilised rice bran absorbs and immobilises free-and extra-cellular water together with extra added formula water.

For all these variables, rice bran can be considered a welcome tool for alternative solutions while significantly improving bottom-line performance and economics. The properties of functional ingredients in complex meat emulsion systems are very important since their performance can either be beneficial or detrimental. There are a number of variables that can affect the performance of rice bran.

All emulsified meats, such as bovine and pork, go through a finely comminute process which ultimately leads to gelation, which itself is a two-step heat treatment process involving dissociation of the protein molecule, followed by the second step in which aggregation forms a gel network or matrix.

In principle, heat-induced gels can be divided in two types - thermoset or irreversible and thermoplastic (reversible). Emulsified meat products always are considered thermoplastic gels. The properties of solubilised meat proteins and to a certain degree also the swollen myofibril proteins, together with added non-meat protein ingredients play a very important role at surfaces or interfaces. Nearly all food products that contain immiscible substances such as water and oil/fat need protein to maintain product integrity. Solubilised myofibril protein and some other functional animal or vegetable protein ingredients have a certain molecular structure that provides an affinity for substances on either side or the interface. The result is an emulsion. Emulsification is the process of one...
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Liquid being dispersed as small droplets or globules within the other. The water phase may be a solution of salt, sugars and other water-loving or hydrophilic ingredients such as the fibre fraction of rice bran. The oil phase may contain fats, oil and other lipophilic substances such as the rice oil fragments of the rice bran. The emulsion itself will become an important structural part of the matrix.

Proteins are amphiphilic macromolecules, i.e. they have hydrophilic and hydrophobic regions. The hydrophilic region is usually referred to as the head group, and the lipid portion is known as the tail end. This is the principle molecular basis for interactions at the water and oil interfaces. Thus proteins can be considered to act as surfactants in forming emulsions, foams and stabilising meat batters.

All emulsifiers have an electrically charged, or polar end, and a non-charged, or non-polar end. The polar end is hydrophilic whereas the non-polar end is lipophilic. The resultant water-oil mixture is that the emulsifier dissolves part of itself in water and the other part in oil. Energy is required in the form of a high-speed rotating knives or blades to reduce the fat or oil into small particles, preventing coalescence and allowing absorption of the protein ingredient and subsequent formation of a stable emulsion. What sets stabilised rice bran apart from typical vegetable proteins is that its rice fibre fragments are very eager to absorb water, while the rice oil and rice protein provide a stable, fat-filled "emulsion" that does not cause additional formula stress. Knowing this, it is important to first optimise extraction of the myofibrillar salt soluble protein by salt, phosphate together with the appropriate amount of water or ice.

However, the functionality of rice bran goes beyond water absorption properties of the fibre component. By separating the rice fibre by means of centrifuging from the oil and protein fractions, the direct influence and properties of the single rice fibre can be measured. The water holding capacity of rice fibre itself is not significantly better than other fibres such as derived from corn, potato and oat. Of course, the fibre fraction is a welcome bonus, but it will not fully explain the superior binding or stabilising properties of rice bran. There is more than meets the eye. As a side note: rice bran, like soy concentrate, also contains fibres. However, unlike soy protein concentrates, rice bran does not contain unfavourable residual carbohydrates such as starch and oligosaccharides raffinose that may cause flatulence and negative soy flavour taste associations.

The term functionality refers to the functional demands made on food and meat products. For example, the desired properties such as fat binding, water holding and structure forming capabilities. It is clear that these func-
tional requirements are only marginally related to similar physicochemical protein and fibre properties in aqueous solutions. Subsequently, this means that functional requirements are frequently solved by trial and error through additions or elimination of arbitrarily selected functional ingredients. And yes, for every new sausage formula this empirical procedure has to start all over from base one.

Meat technologists have grown up by determining the ‘performance quality’ of soy isolate and soy concentrate by making pre-emulsions like 1:5 and 1:4:4. For example, by emulsifying 5 parts of water and 5 parts of fat with 1 part of soy isolate, a quick indication is obtained how the fat and water holding capacity performed under pasteurisation or sterilisation conditions. Likewise, combining 3 to 4 parts of water with 1 part of soy isolate would give an indication about consistency and gel strength. When a new functional ingredient arrives on the scene, it is only logical that meat technologists evaluate in a similar fashion. For stabilised rice bran, measuring emulsification and gel strength is based on a different mechanism. Rice bran is a unique integrated combination of protein, oil and fibre that are configured to independently react with most constituents of a meat emulsion. Moreover, the individual components of the rice bran synergistically react with the meat emulsion, aggregates upon heating of the product. Most likely, when the heat treatment cycle reaches about 50°C and higher, the individual components react and provide structure and stability to the emulsion. Like is the case with other emerging novel ingredients, most data use empirical observations. True scientific reports will no doubt follow a few years from now. In the meantime rice bran is quickly gaining acceptance, and reformulated sausage and coarse ground meat products are being introduced in a rapidly increasing number of countries. It has been determined that rice protein enhances emulsification capacity by stabilising or immobilising the fat/oil droplets that are finely distributed throughout the meat stuffing (batter) matrix. The protein content of rice bran (15%) is about the same as wheat whey powder. Why protein is very suitable to mimic fat globules (formation of micro-particles) that are known to improve mouthfeel, texture and general rheological properties. Sweet whey powder including the denaturing versions have been used for a great many years in food and meat products and together with rice bran the combination offers beneficial effects. The ability of rice protein to encapsulate oil while maintaining structural integrity enhances its value throughout the thermal processing cycle for stability, improving yield and or reducing purge while reducing costs.

Inclusion levels

For premium emulsified meat products, an inclusion level of 1% to 2% stabilised rice bran is sufficient. This ingredient performs best when added in dry form directly into a chopper or mixer-blender. Coarse or granular forms of stabilised rice bran are most suitable, since they don’t cause dusting but can provide almost immediate particulate breakdown and rapid hydration with the assistance of blending or chopping friction. Unlike soy protein isolate, which at increasing levels of addition has a tendency to proportionally increase pH and weaken meat colour, rice bran will not affect these variables. On the contrary; because of the strong anti-oxidative properties of rice bran, shelf life and colour generally improves in cooked meats. Also formula that is based on mechanically deboned chicken or turkey meat requires a relatively low inclusion level of rice bran < 2.0%.

Emulsified meat products that are formulated on a low amount of lean meat content, i.e. less than 30%, typically require inclusion levels of 3%. Sausages with even lower lean meat content can be formulated using soy protein isolate to enhance gelation, while using rice bran to immobilise water while safeguarding sensory properties such as texture. For these low-meat emulsified sausage, and inclusion level of 3% functional soy protein and 2% rice bran generally is a good starting point. It is generally known that high inclusion levels of soy protein isolate reduce the typical cured colour of processed cooked meat products. In comparison, rice bran will somewhat darken the cured colour though the colour darkening is less intense as the possible colour lightening of soy protein based formulas.

After 2 and 4 weeks of refrigerated storage, the purge is significantly lower when rice bran is used at 3% compared to the control product. Increasing the refrigerated storage to 12 weeks, the formulation containing as little as 1.5% rice bran showed also significant less purge, compared with the base control formula. Although rice bran perfectly can be used as a stand-alone functional ingredient in emulsified and coarse ground meat systems, combinations with dairy protein, soy protein, hydrocolloids and dehulled mustard flour are organoleptically well balanced and provide very satisfactory yield results.

In terms of shelf life it can be noted that rice bran contains considerable amounts of anti-oxidative flavonones, now to mention the inherent benefits of superior freeze/thaw properties for hot dogs sold to the so-called “wet markets” in most Asian countries for refrigerated storage of up to 90 days. It is a fair and true conclusion that rice bran does not offer as high emulsification capacity as some animal or vegetable proteins, and does not equal water binding properties as certain fibres, such as present in corn. However, at moderate levels of inclusions, rice bran most certainly provides excellent functional solutions with regard to cost, texture and flavour when used in a wide range of emulsified meat products. The optimum level of added rice bran mainly depends on the lean meat and fat level. For high lean meat sausage, usually an inclusion level of 1.5% will be sufficient. For medium lean meat and a fat level of approximately 25%, usually 3% inclusion suffices. At these levels, the end product generally show similar yields as control product made with soy isolate. The same is true for properties such as texture, chewiness and hardness. However, taste panels select stabilised rice bran formulated formula because of a more meaty appearance and a preferred sweet note. Generally speaking, consumers prefer the slight sweet note compared to the typical soy flavours that filter through when used at high levels of inclusion.

Sensory evaluation showed that trained panelists were unable to detect differences be-
between base control without added functional ingredients, and the various text products containing from 0.5% to 3% rice bran for interior firmness, interior cohesiveness and rancidity during the entire storage period of up to 90 days. However, it should be noted that an inclusion levels of 3% and higher, the sausage is perceived somewhat less juicy compared to the control formula. This is probably due to the drying effect of water insoluble fibre. Because of the many variables such as specific type of processing equipment, formulation and availability of raw materials, it is very difficult – almost impossible – to give precise application and dosage information. For example, soy concentrate generally performs better in a low-energy emulsion system, while soy protein isolate performs better in a high-energy emulsifying system.

**Protein and flavor encapsulation**

Proteins and some other functional ingredients contribute to physicochemical properties that guide the behaviour and performance during emulsion preparation, heat treatment, storage and finally, meeting or exceeding consumer expectations. It is known that extrinsic conditions such as temperature, pH, salt, phophates, hydrocolloids, surfactants and water, together with processing variables can greatly influence performance dynamics. For example, the availability of sufficient free water is often neglected during emulsification when the presence of ingredients and additives compete for water, creating too much friction early on in the processing cycle.

In addition to protein’s complex conformational structure assembling a coherent and stress-stable emulsion or meat matrix, proteins are also an important source for interactions with flavour compounds. This feature can be synergistic or antagonistic. Flavour encapsulation by protein can protect unwanted flavors to filter through during heat treatment, storage and point of consumption. It is a well-known fact that dairy proteins are superior in protecting and enhancing undesirable flavour development because of their good rheological and surfactant properties. Additionally, it should be mentioned that, especially whey protein has the ability to bind fat by means of forming micro-particulates. Soy protein on the other hand, is considered antagonistic, when it comes to undesirable flavors. Specifically the medium-chain aldehydes bring out the bean off-flavour of soy protein ingredients. Stabilised rice bran is notably better to balance flavour. A perfect solution would be a small amount of non-fat dry milk powder, sweet whey powder to balance flavour fancies’. Extensive consumer paneling has indicated that strong preference is given to hot dog products formulated with stabilized rice bran mainly because of the lack of desacque and undesirable soy flavors.

**A case study**

It is no secret that meat processors are faced with a balancing act between choosing ingredients that deliver performance and achieving the health-benefit positioning they need. In a best-case scenario, consumers get nutritional enhancement, processors get improved product and producers get cost savings. A number of research studies at several leading universities, the Meat and Fat Research Institute in Poland and in pilot- and full-scale in-plant evaluations in United States, Europe and the Philippines have confirmed the ability of rice bran to immobilise or bind water at high intensity for a longer period of time than soy isolate – up to an inclusion level of 3%. Cost-driven markers are constantly searching for ways to stimulate a quality product at a price that suits consumer’s purchasing power. Stabilised rice bran was introduced to the EU countries in 2008. At time of writing rice bran is now well accepted in countries such as the UK, Netherlands, Czech Republic, Hungary, Romania and the Baltic states. From here the growth will progress allowing cost reductions without diluting quality and nutritious profile the customers have come to expect. For example: This new innovation is a welcome addition to the world of processed meat. In the Philippines the hot dog is the number one processed meat with a total of 750 m t being produced per day across the country. During difficult times of increasing prices on all raw materials this will come as a two way benefit to the consumer gets the nutritional enhancement and improved finished product while the producer gets the cost savings. In recent times the increasing cost of raw materials have fallen on the producer who simply can’t pass the increase on to the market due to the static daily salary of the masses in the lower end of consumer market segments. Fear of doing so and losing market share are great resulting in a steady dilution of margins. Asian countries, including China, have picked up on the inherent quality and application properties of rice bran. During actual meat emulsion processing it has been determined that, when used, rice bran is an ideal ingredient to manipulate thermodynamic considerations. It is a well-known fact that each and every meat emulsion has a certain preferred time-temperature optimisation in which processing equipment and ingredients can be used to reach preferred temperature specifications. Immediately after the adding rice bran to a chopper or blender, the rice fibre starts to attract water and swells. This phenomenon can be described as a gritty look and feel. However, during the cook cycle, the gritty appearance and taste will disappear totally. As is true with soy protein isolate, high inclusion levels of stabilised rice bran will affect typical cured meat colour. High inclusion levels of soy isolate generate less curing colour as a result of less availability of meat myoglobin and the influence of soy’s high pH. For rice bran, it is the colour of the ingredient itself high inclusion levels tend to darken product color somewhat; colour enhancer (e.g. fermented rice (Monascus purpureus; anna, ang- lák or red koji), beet root extract, blood albumin, sandalwood extract, paprika extract, crypthrome, carnae or Red2G), many of which are also used with soy ingredients, can easily correct this problem. Preferably, stabilised rice bran should be added to the chopper just after the fat. The bran hydrates rapidly, so it is important to ensure that sufficient free processing water is available so as not to ‘overheat’ the emulsification temperature.

Compared with soy protein-added hot dogs, rice bran-formulated products are much softer in texture. However, flavor scores are much better than soy protein isolate controls. A hot dog with rice bran seems to hold flavour improvements, and as an added bonus, appears to be noticeably sweeter. For premium hot dogs, where lean meat and fat totaling 60%, up to 2% soy protein isolate can be replaced weight-for-weight with stabilized rice bran. Again, it may be necessary to slightly alter emulsion colour, but in sampling the finished products no sensory panel members could detect which product was the soy protein isolate control and which was the rice bran test.

Ideally, rice bran can be added as a non-dusting dry powder without complicated pre-emulsion or pre-gel preparations that are often required when soy ingredients are used. The ingredient is label-friendly, with no allergy or GMO issues. Plus, stabilized rice bran’s protein is nutritionally equal to other vegetable protein sources – at significantly lower price points.

**Future expectations**

Looking into the crystal ball: what is ahead for stabilised rice bran as a functional ingredient considering both usage and pricing? At this point of time, the full picture is complicated, but long-term trends are very encouraging. For starters, rice bran al-
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