the flavor perceptibility of monounsaturated aldehydes having the same chain length (Table III), we found alternating odor and taste threshold values for the *trans*-(n-x)-heptenals and *cis*-(n-x)-nonenals (5). Minimal values were determined for *trans*-3- and *trans*-5-heptenal, and for *cis*-4- and *cis*-6-nonenal. The *trans*-nonenals showed only an alternating effect for the taste threshold values; minimal values were for *trans*-4- and *trans*-6-nonenal. The odor threshold values for the *trans*-nonenals and the odor and taste threshold values for the *trans*-octenals had only one minimum, viz., for *trans*-6-nonenal and *trans*-6-octenal, respectively.

The homologous series of *trans*-2, *trans*-(n-3)-alkadienals (Table IV) had one minimum for the odor and taste threshold value, viz., for *trans*-2-*trans*-6-nonadienal.

Earlier investigations (6), in which the thin layer chromatographic behavior of these unsaturated aldehydes were studied as 2,4-dinitrophenylhydrazone derivatives on silver-nitrate-impregnated chromatoplates, showed similar results. However, no answer has been found yet in what way these thin layer chromatographic phenomena can be collated with the odor and taste aspects of unsaturated aldehydes in the free state. Basic organoleptic investigations of these compounds, using animal odor and taste receptors, might better elucidate the mechanism of smelling and tasting.

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Rapeseed Meal in Animal Nutrition: II. Nonruminant Animals[1]

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ABSTRACT

On the basis of our present knowledge regarding the use of rapeseed meal in rations for swine and poultry, it would appear that the usage levels for high glucosinolate and low glucosinolate rapeseed meals discussed in this paper should give excellent results in terms of performance.

INTRODUCTION

Undoubtedly, the most important factor that has contributed to expansion of usage of rapeseed meal (RSM) in feeds for swine and poultry in recent years has been the development of low glucosinolate (LG)-type rapeseed (RS) by Canadian and European plant breeders. Releases of LG cultivars of RS in Canada have been more rapid than in Europe and, as a consequence, Canada has led the world in production of this type of RS. About two-thirds of Canada's 1979 crop of 154 million bushels of RS was of LG type. It is expected that ca. 80% of Canada's 1980 crop of RS will be of the LG cultivars Tower, Regent, Candle and Altex.

Because RSM derived from LG-type RS has been shown to be decidedly superior for feeding purposes to meal produced from high glucosinolate (HG)-type RS, which is still grown in many countries of the world, the Canadian RS industry has settled on the name "Canola meal" to identify RSM produced from Canadian LG-type RS. All of the RSM currently being produced in Canada is of LG type.

COMPOSITION

Protein and Amino Acids

The protein content of RSM varies, depending on the cultivar from which the meal is produced. The protein content of RSM from Candle RS runs around 35% whereas that from Tower, Regent or Altex runs 38-39%.

The amino acid composition of LG-RSM does not differ from that of HG-RSM (1). From the point of amino acids in RSM vs those in soybean meal (SBM), RSM protein is lower in lysine and higher in sulfur-containing amino acids than SBM. As a consequence, these two protein-rich feedstuffs tend to complement each other when used together in rations.

Studies on the variability in the quality of the protein of commercial RSM have been undertaken,. In this connection, Goh et al. (2) found a high correlation between the dye-binding capacity of the protein (DBCP) of RSM with Acid Orange 12 and the basic amino acid contents of the meals. However, in subsequent studies of the DBCP of a large number of commercial RSM and their total protein efficiency ratios for chicks, no relationship was evident (3). It was concluded from this study that Canadian RS processors are producing RSM of consistently high quality.

TABLE I

Recommended Levels of Use for Rapeseed Meal for Nonruminant Farm Animals

	High glucosinolate (%)	Low glucosinolate (%)
Swine		
Starter, grower, finisher	5	10
Breeder	3	—[a]
Chickens		
Starter, grower	15	20
Layer, breeder	5	10
Turkeys		
Starter, grower	10	20
Breeder	10	10

[a]May be used as the sole source of supplementary protein.

[1]Presented at the ISF/AOCS World Congress, New York City, April 1980.

Ether Extract

The ether extract of Canadian RSM tends to be higher than that from SBM (1). This is because in Canada, RS gums are added back to RSM at about the 1.5% level. The gums are obtained during the refining of RS oil and consist of glycolipids and phospholipids and variable amounts of, e.g., triglycerides, sterols and fatty acids. Addition of gums to RSM should increase the energy value of RSM and, as a consequence, be beneficial. Experimentally, addition of up to 6% of RS gums to RSM has been shown to have no detrimental effects on the feeding value of the RSM for broilers or layers (Clandinin et al. [4] ; Leeson et al. [5] ; Summers and Leeson [6] ; March et al. [7] ; March and Soong, [8] ; and Summers et al. [9]).

Mineral

Generally speaking, RSM is a richer source of minerals than SBM (1). However, it has been shown by Nwokolo and Bragg (10) that the phytic acid and fiber in RSM reduces the availability of P, Ca, Mg and Zn. In addition, it was shown that crude fiber also decreases the availability of Cu and Mn. In spite of the lower availabilities of minerals in RSM vs those in SBM, RSM was shown to be a better source of available Ca, Fe, Mn, P, Se and Mg than SBM, whereas SBM was shown to be a better source of Cu, Zn and K than RSM.

Glucosinolates

The glucosinolate content of LG-RSM is only about one-eighth that of HG-RSM (1). In this regard, in our laboratories at the University of Alberta, 10 samples of Tower and 3 samples of Candle RSM were found to contain 1.04 and 0.62 mg/g of glucosinolates whereas Bell and Jeffers (11) have reported average values for Canadian HG-*B. napus* and HG-*B. campestris* RSM of 8.5 and 6.3 mg/g, respectively. While the glucosinolates present in LG-RSM do cause minor thyroid enlargement (12) and slightly reduced iodine transfer to eggs, (13) these effects are not considered to have practical significance. Indeed, if as much as 30% of LG-RSM was included in a ration, the content of potential L-5-vinyl-2-oxazolidinethione (OZT) in the ration would be considerably less than that shown by Von Vogt and Stute (14) in Germany, to be necessary in the rations of chickens to cause undesirable effects in laying chickens (225-600 ppm OZT) which have a lower tolerance for OZT than broiler chickens (700-1050 ppm OZT).

Energy

On the basis of data collected recently in Canada on the metabolizable energy (ME) value of Tower RSM (15,16) it would appear that 1,900 kcal/kg and 2,000 kcal/kg are appropriate ME values to use for growing and adult poultry, respectively. The established ME value for RSM for swine is 2,700 kcal/kg (17).

Efforts to produce RSM of ME content approaching that of SBM have been made in Canada, France and Sweden. The Canadian approach has been to remove by regrinding and air-classification part of the hulls in RSM. While the process has resulted in a product with protein and ME values equal to those of soybean meal, it has been found that the high protein meal product is so finely ground that it causes feeding problems. In contrast, French and Swedish workers have removed the hull from the seed before oil extraction and have been able to produce a high protein product that appears not to possess the undesirable characteristics of the Canadian product. Vermorel and Baudet (18), in a study involving rats, showed that by reducing the fiber content of RSM by 60% by the French process of dehulling, the digestibility of RSM protein and the ME content of the meal were increased to those of SBM. One disadvantage of the European approach, however, lies in the fact that a small amount of oil is lost in the hull fraction. French and Swedish workers have both reported, however, that the fat content of the hulls enhances the feeding value of the hulls for ruminants.

Because tannins in RSM are considered to have antinutritional effects and because they are located in the hulls of RS, an additional advantage in removing the hulls from RSM or RS lies in the fact that the hull-free meal would be essentially free of condensed tannins. This may partially account for the increased nitrogen utilization from dehulled RSM noted by Vermorel and Baudet (18).

Canadian plant breeders are also trying to improve the ME value of RSM by lowering the fiber content of RS. It is claimed that introduction of a yellow seed coat should reduce the fiber content of RSM from 12 to 9%. However, perhaps because of such factors as field contamination, inadequate seed cleaning and the stage of development of the yellow-seeded variety (Candle), we have not observed much difference in the fiber levels in RSM derived from brown- or yellow-seeded RS.

USE IN RATIONS FOR SWINE AND POULTRY

Swine

One of the main drawbacks of HG-RSM for ruminants and swine has been its low palatability. In this regard, if these classes of livestock have a choice between eating a ration containing HG-RSM or one containing SBM, they will choose the SBM ration. However, when there is no choice, these classes of livestock readily consume rations containing recommended levels of HG-RSM. Nevertheless, one has to recognize that the problem exists. Fortunately, this problem has, for all practical purposes, been resolved by the introduction of LG-RSM. Research in Canada at various Universities and Canadian Experimental Stations has shown that LG-RSM is much more palatable to swine (19) and cattle (20) than HG-RSM. Workers in France (21,22) have also reported that RSM from which most of the OZT and isothiocyanates have been destroyed by making an ensilage of RSM and corn is more palatable to pigs than the RSM in which the glucosinolates are present.

Starting, Growing and Finishing Swine

At a symposium on RSM held in Canada, Aherne et al. (23) reviewed the many published papers and progress reports to which he had access which dealt with the use of RSM in rations for pigs. After giving due consideration to the research reviewed, he concluded that, for starting, growing and finishing pigs, LG-RSM (Tower) could be included in starting and growing rations at about the 10% level and as the sole source of supplementary protein in rations for finishing pigs. This recommendation relative to starting and growing rations appears conservative when one considers the study of Von Petersen and Schulz (24) in Germany, in which levels up to 24.6% of LG-RSM (Erglu) were fed to starting and growing pigs without affecting growth or market quality adversely.

Breeding swine. HG-RSM has had a bad image as a feedstuff for breeding pigs. Results obtained in the past on RSM of varying glucosinolate content have suggested that problems observed in breeding pigs have been related to the glucosinolate contents of the meals. This is borne out by three experiments recently conducted in Canada. In the first experiment, Flipot and Dufour (25) fed gilts rations containing 10% of LG-RSM (Tower) or a comparable level of

SBM throughout gestation and lactation and found that the gilts fed the LG-RSM-containing ration performed just as well as those fed SBM. In the second study by Hartsock (26), LG-RSM (Tower) was supplied as the sole source of supplementary protein from 60-kg liveweight through the first lactation. No significant differences were noted in services per conception or litter size at birth or at weaning between the LG-RSM-fed gilts vs the SBM-fed gilts. In the third experiment, Lewis et al. (27) used 72 cross-bred gilts to evaluate LG-RSM, derived from Tower RS, as a partial or complete replacement for SBM in rations for gilts from 20-kg liveweight through two gestation and lactation periods. The results indicated that LG-RSM may be used as a complete replacement for SBM in rations for pregnant and lactating swine for at least two reproductive cycles with no reduction in sow reproductive performance. These results suggest that LG-RSM is a satisfactory source of protein for breeding pigs and that no reduction in performance is likely to occur from use of high levels of same in rations for gilts and sows during gestation and lactation.

Poultry

A great number of reports have been published on work conducted in Canada at the University of British Columbia, University of Alberta, University of Manitoba and University of Guelph on the use of LG-RSM in rations for various classes of poultry. It will be impossible, in the time allotted, to cite the individual workers; however, we will try to draw conclusions from their collective efforts, and, insofar as possible, give credit to the institutions where most of the work was done. In addition, we will cite European work that seems relevant.

Chicken broilers. Extensive studies have been conducted with broiler-type chickens at the University of Alberta and the University of Guelph involving LG-RSM prepared from the Bronowski, Tower and Candle cultivars of RS. These studies (12) have shown that up to 20% of LG-RSM may be included in rations for broiler chickens without adversely affecting growth or feed conversion, provided, of course, that the low ME value of RSM is compensated by suitable energy adjustments in the rations. In a study reported by Marangos et al. (28) in England, it was shown that when moderately low, medium and high glucosinolate RSM were fed to broilers at the 12% level of inclusion, similar growth and feed conversion responses were elicited. This agrees with Canadian data on similar types of RSM (29). Von Vogt and Stute (14), in Germany, have related performances in broilers to the OZT content of the ration, suggesting that broilers tolerate 700-1,050 ppm of OZT in the ration. This is well above the amount of OZT that would be found in rations containing 20% of LG-RSM. Von Vogt (30) has shown that 20% of LG-RSM (Erglu) can be used in broiler rations without adverse effects on growth or feed efficiency.

Workers in France (31) have obtained superior results with LG-RSM. When LG-RSM was included in a broiler ration at the 20% level, growth and feed conversion comparable to that of the birds fed a control diet based on SBM were obtained.

Turkey broilers. A limited amount of work on the use of LG-RSM in rations for growing turkeys has been reported. Data from the University of Alberta (12) and the University of Guelph (32), and from Salmon (33) suggest that as much as 20% of LG-RSM may be included in the rations of turkey broilers without adversely affecting growth or feed/gain ratio.

Turkey breeders. In a two-year study, Robblee and Clandinin (34) showed that 10% of HG-RSM could be used in rations for breeding turkeys without causing adverse effects on egg production, feed conversion or percentage hatchability. No reports on the use of LG-RSM in rations for breeding turkeys have been published.

Chicken layers. Numerous studies (12,35-38) at Canadian universities have shown that at least twice as much LG-RSM may be included in rations for layers as previously found (29) for Canadian-type HG-RSM. In some experiments (7,9,12,39) levels of inclusion as high as 20% of LG-RSM have been found to cause no adverse effects on productive traits. However, in order to err on the conservative side, the 10% level of inclusion has been selected as the recommended level for LG-RSM in chicken laying and breeding rations.

In Germany, Von Vogt and Torges (40) and Von Vogt (30) have reported that feeding up to 15% of LG-RSM (Erglu) had no significant influence on mortality or productive traits of white egg layers. On the other hand, feeding up to 15% of HG-RSM (Lesira) increased mortality and worsened performance.

Fishy eggs. Hobson-Frohock et al. (41) were the first to show that the fishy odor resulting from the inclusion of RSM in the ration of brown-shelled egg layers was due to the presence of trimethylamine (TMA). Affected birds are apparently unable to oxidize TMA to odorless TMA-oxide rapidly enough to prevent TMA from being deposited in their eggs. Griffiths et al. (42) have shown that the fishy odor is detectable, organoleptically, when eggs contain more than 0.8 ppm of TMA. Overfield and Elson (43) demonstrated that the level of RSM in the laying ration of brown-shelled egg layers influenced the degree of fishy odor and suggested that the ability of the bird to metabolize TMA was genetically controlled. Bolton et al. (44) showed that predisposition to laying fishy eggs was the result of the presence of a semidominant gene that has variable expression, depending on environmental factors. In this regard, our studies have shown that brown egg layers fed rations containing RSM and kept in floor pens are more likely to lay fishy eggs than those maintained in laying batteries.

Hobson-Frohock et al. (45), Clandinin et al. (35) and Mueller et al. (46) have reported that the source of the TMA in such eggs is sinapine which is present in rapeseed meal at a level of ca. 1-1.5% (47,48). Mueller et al. (46) showed that organisms present in the caeca of hens are capable of converting the choline moeity of sinapine to TMA. Goh et al. (49) have shown that, to prevent brown egg layers from laying fishy eggs, the level of sinapine in laying rations should not exceed 0.1%.

Pearson et al. (50) have proposed a method involving injection of $[^{14}C]$ TMA intravenously and measuring plasma levels of $[^{14}C]$ TMA-oxide for detecting potential fishy egg layers. The method could prove useful in poultry breeding.

Evidence (51,52) has been presented which suggests that goitrogens in RSM may be involved as secondary factors in producing disturbances in TMA metabolism that causes the laying of fishy eggs. Leeson and Summers (53) reported that inclusion of 1.5% of gums in rapeseed meal increased the incidence of fishy odor in eggs from brown egg layers and suggested that the high choline content of gums may be the factor responsible for the increased incidence of fishy odor. March and MacMillan (54) have shown that at high levels of inclusion, choline can cause susceptible birds to lay fishy eggs. However, Goh et al. (55) reported that at usual levels of choline supplementation, free choline is not a factor in the fishy egg problem.

Because it has been shown by Goh et al. (55) that when hydrolyzed sinapine is included in a laying ration it does not cause susceptible birds to lay fishy eggs, attempts have been made to develop a simple practical method for hydrolyzing the sinapine in RSM. In this regard, it has been found (55,56) that sinapine is easily hydrolyzed by alkali; calcium hydroxide or ammonia in the presence of water markedly reduces the sinapine level in RSM. It is thought that if ammonia treatment could be incorporated in the desolventizing process, hydrolysis of the sinapine in RSM might be effected at little cost.

Another possibility for reducing the fishy egg problem would be through development of RS cultivars free of sinapine. In this connection, Mueller et al. (48) have shown variation in sinapine content ranging from 1.22 to 2.26%.

Hemorrhagic liver syndrome. Because association of RSM with hemorrhagic liver syndrome (HLS) by Jackson (57) and Hall (58,59) and the suggestion by Hall that the hemorrhages could be caused by lysis of the reticular substance of the liver which weakened the structure of liver, further studies have been undertaken. Contrary to Hall's contention, studies by Yamashiro et al. (60) suggest that lysis of hepatocytes and perhaps vascular changes followed by distortion of reticulum in the liver leads to hepatic hemorrhage.

On the subject of the factor(s) in RSM which predispose susceptible birds to HLS, Marangos et al. (28) reported a higher incidence of mortality in layers fed rations containing *B. napus* rather than *B. campesteris* RSM. Although the OZT content of the *B. napus* meal was higher than that of the *B. campestris* meal, the higher HLS from the *B. napus* was not attributed to higher OZT because *B. juncea* meal, which has no OZT, caused a high incidence of HLS. March et al. (61) and Olomu et al. (62) have observed that high levels of HG-RSM caused excessive mortality due to HLS in layers.

Clandinin et al. (35,63) reporting on their own data and those of Campbell (64), indicated that, in addition to level of HG-RSM, the strain or breed of layers affected the incidence of HLS. Slinger (65) made a similar observation with respect to two strains of Leghorns. Grandhi et al. (66) have confirmed that the level of glucosinolate in the ration affects the incidence of HLS.

While specific factors in RSM which are responsible for this problem have, as yet, not been identified, it seems quite clear from work just discussed that the level of glucosinolates and/or their hydrolysis products cause HLS. In this regard, Papas et al. (67) have suggested that intact glucosinolate in the presence of the nitrile, 1 cyano-2-hydroxy-3-butene predisposes to HLS. Some reduction in the HLS was obtained by these workers by supplementing rations containing RSM with extra vitamin K.

Full-Fat Rapeseed

Ordinarily, full-fat RS is not considered a feedstuff for livestock and poultry. However, at certain times it could prove economically sound to include ground or unground full-fat RS in rations for various classes of livestock and poultry.

Most of the feeding studies on full-fat rapeseed have been done at the Universities of Guelph and Alberta. Early work involving RS with moderately high or high glucosinolate content suggested that such full-fat rapeseed was not a satisfactory feedstuff for pigs (68,69) and that only after heat-treatment was it a suitable feedstuff for inclusion in broiler rations up to the 10% level and in laying rations up to the 5% level (70-72). However, more recent work at the University of Guelph (73,74) indicates that broiler chickens, broiler turkeys and laying hens may be fed up to 20, 20 and 10%, respectively, of LG-RS (Tower) in their rations without adversely affecting productive traits. Grinding and heat treatment (121 C for 30 min) of the RS are recommended when full-fat RS is included in rations for chicken and turkey broiler rations, but does not appear necessary when the full-fat RS is used in laying rations. However, the work of Josefsson and Uppstrom (75), in which is was shown that even LG-RS (Bronowski) must be heat-treated to avoid nitrile formation, suggests that for safety's sake, even LG full-fat rapeseed should be heat-treated before being fed.

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Production and Use of Natural Antioxidants[1]

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ABSTRACT

We have developed a new industrial process for obtaining natural antioxidants from spices and other vegetables by primarily adapting mechanical and physical treatments. Rosemary, sage, paprika, nutmeg and cocoa shells have been submitted to a mechanical treatment (micronization), and the finely powdered material was extracted with an edible vegetable oil, i.e., groundnut. The antioxidant dissolved in the lipid phase was collected by two-stage falling film molecular distillation to separate the lipid phase to be recycled) from the active, low molecular weight fraction. Antioxidant activity was measured for fats, oils and fat-containing foods by oxygen absorption, head-space analysis (i.e., pentane) extent of secondary degradation products and organoleptic evaluations. Results obtained indicate that molecular distillates from spices, i.e., rosemary derivatives, effectively protect foods against oxidative rancidity.

INTRODUCTION

It is known that crude lipid extracts from selected leafy materials are stable to autoxidation despite their high linolenic acid contents. This resistance to oxidation appears to be due to the presence of active naturally occurring antioxidants, probably of the phenolic and polyphenolic class. Extracts of many plants have been shown to have varying degrees of antioxidant activity in oils, fats and fat-containing foods. For example, cocoa shells (1-3), roasted coffee powder and coffee constituents (4,5) (caffeic acid and quinic acid), and cereals such as oats, barley, malt and rice bran (6-8) have all been described as bearing antioxidant materials.

The antioxidant properties of herbs and spices are also well known: red chili, cinnamon leaf, turmeric, clove, black pepper, nutmeg, dry ginger, rosemary, sage and paprika are reported to retard the development of rancidity in oils. Chipault (9) reported a study of 32 common spices used as antioxidants in lard, and showed that only rosemary and sage are effective as antioxidants. The use of rosemary extracts as an antioxidant in foods has already been reported by Rac and Ostric (10), Berner and Jacobson (11) and Chang (12,13). The antioxidant activity of spices is dependent on the recovery technique, i.e., the type and polarity of solvent, particle size of the antioxidant-bearing material and extraction parameters, used for their isolation. In order to clarify the fat-stabilizing constituents of spice extracts, Palitch (14) compared the activity of whole extracts, residues and extract fractions, and found significant differences in the antioxidant activity. The problems related to the recovery of natural antioxidants concern mostly the proper choice of starting material, an effective extraction procedure capable of giving active, odorless, colorless antioxidants and the use of methods to screen and evaluate their activity.

We describe here a new technique to recover natural antioxidants from spices and vegetable material (i.e., rosemary and cocoa shells) based on the following steps: micronization of antioxidant-bearing material in an edible oil to obtain a mechanical transfer of the antioxidant to the lipid phase; cleaning the lipid phase by filtering or centrifuging; and molecular distillation on falling film or centrifugal systems to collect the low molecular weight, active components, which deodorizes and partially bleaches them.

Variations in processing factors such as lipid phase composition, use of codistillants and molecular distillation parameters have also been investigated so that we can define a standard process for obtaining natural antioxidants

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